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BREAK IN NO. 2 HYDRAULIC TURBINE AT WACHUSETT POWER STATION, CLINTON, MASS.

BY WILLIAM E. FOSS, CHIEF ENGINEER, METROPOLITAN WATER WORKS.

[Read March 12, 1919.]

The Wachusett Power Station of the Metropolitan Water Works is situated just below the Wachusett Dam in Clinton.

The building is of granite masonry, 100 ft. in length by 70 ft. in width, and the easterly portion is used for the Wachusett Department offices. The superintendent's office is on the second floor, and the civil engineering office is on the third floor, with a loft above it.

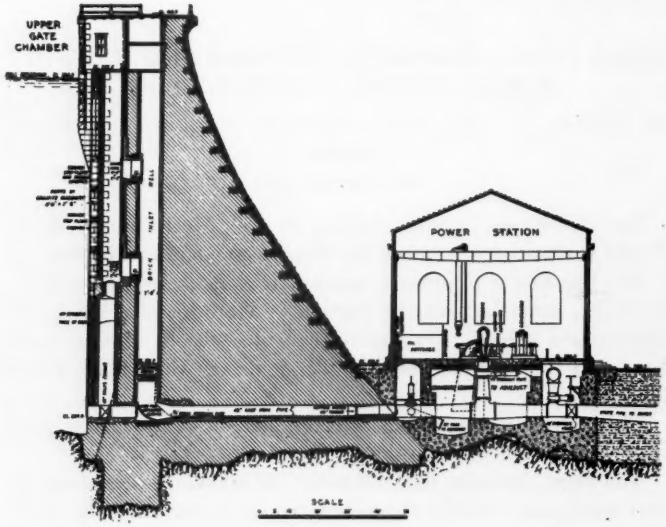
The hydro-electric machinery is on the first floor, which is about 92 ft. below high water in the Wachusett Reservoir.

The plant includes four 1 000-kw., 13 800-volt alternating-current generators, directly connected with horizontal-shaft hydraulic turbines, which operate at a speed of 400 revolutions per minute, and two 60-kw., 125-volt direct-current exciter generators also operated by hydraulic turbines. Each of the main turbines is provided with a type Q Lombard governor, arranged for automatic or hand operation as desired.

The water supply for each unit enters the gate chamber through ports in the upstream face of the dam, and after passing the screens enters a vertical circular well 7 ft. in diameter through two openings, each 6 ft. high and 2½ ft. wide, which are provided with sluice gates arranged for operation by hand or by electric motor, as desired.

From the bottom of the circular well the water flows through a horizontal cast-iron pipe 4 ft. in diameter for a distance of 115 ft., to a point under the turbine, and rises vertically 15 ft. to the base of the scroll case. There is a hydraulic gate valve in this riser which can be operated from the power station floor.

When the power station is in operation, energy is delivered to the New England Power Company's lines at 13 800 volts through two circuits, each including 815 ft. of underground cable and



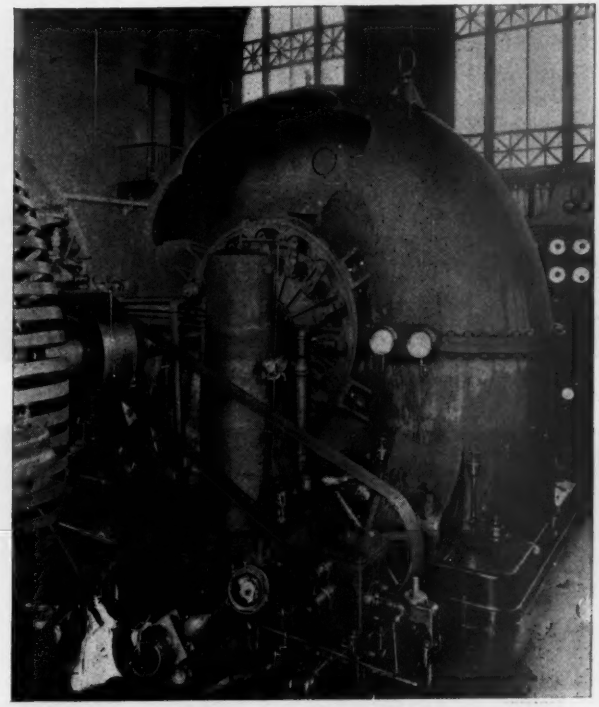
SECTION THROUGH GATE CHAMBERS AND POWER STATION.

600 ft. of overhead line. Energy is also furnished at 2 300 volts through a short length of underground cable and 2½ miles of overhead line to the Clinton Sewerage Pumping Station, which is operated by the department.

When the power station is not in operation the energy required by the department is taken from the New England Power Company's lines.

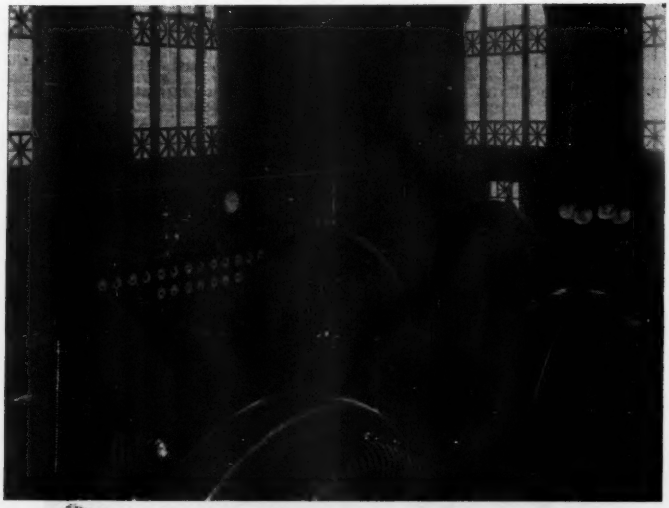
On Monday, February 17, the machinery at the power station was started about 6.30 A.M. as usual, and had been running smooth-

ly with exciter No. 2 and units Nos. 1, 2, and 4 in operation for nearly an hour when the operator noticed that the oil-feed pump of turbine No. 2 was not working properly, and with the helper proceeded to prime the pump with the turbine running.



CLOSE VIEW OF UNIT NO. 2.

Upon throwing off the pump belt, however, some trouble developed, and the operator went to the switchboard and threw the load off of the No. 2 unit. As he was returning, the helper pulled out the governor clutch to change from automatic to hand control, and immediately a section of the upper portion of the scroll case, having an area of 17½ sq. ft., blew out.



VIEW FROM SUPERINTENDENT'S OFFICE.

SUPERINTENDENT'S OFFICE.

The escaping water knocked the helper down and swept him along the floor between No. 1 and No. 2 generators, by the front door, to a radiator near the westerly end of the station, where he was able to regain his footing and left the building through a window. The water was then level with the window sill and about two feet deep over the floor.

Meantime the operator returned to the switchboard and opened all of the electric switches and left the building through the rear door.

The two men then went up to the gate chamber and with the assistance of some other employees closed the sluice gates and stopped the flow of water about thirty-five minutes after the break occurred.

The water flowed out of the opening in the scroll case under a head of 70 ft., probably in a nearly solid stream, which struck the door leading from the superintendent's office to a small balcony in the power station, for it is difficult otherwise to account for the effect of the water, which upset a heavy iron safe about 7 ft. high by 4 ft. wide by 2½ ft. deep, and completely wrecked everything else in the office.

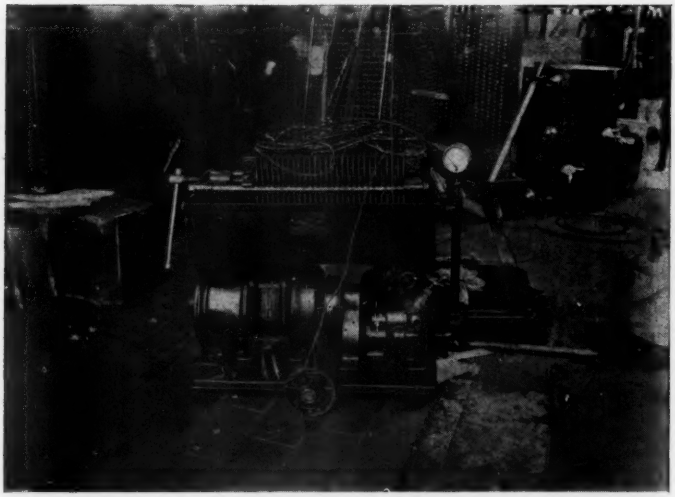
One of the large front windows was broken at a height of about 25 ft. above the floor, and some of the water shot up about 35 ft. above the floor to the top of the room, broke an interior window, entered the loft, and dripped down through the ceiling into the civil engineers' office, but caused little damage.

The water flooded the power station floor to a depth of about 4 ft., broke open the front and end doors and flowed out over the lawn, driveway, and walks into the river. It also broke down a wooden partition at the air shaft and flowed through the iron grating in the floor into the Wachusett Aqueduct.

The heating plant is in the southeast corner of the basement, and there is an opening in the floor above it about 12 ft. long and 6 ft. wide. Water dropped through this opening on to the heater and tore off all of the magnesia insulation and put out the fire. Water also flowed down the stairs at two points into the basement and thence into the river through drain pipes, which appear to have been of sufficient capacity to prevent its filling the basement, as the transformers connected with the Clinton Sewer-

age Pumping Station line, which are located on a shelf under the power station floor, were not disturbed.

The station lighting and power service transformers and many of the instrument transformers were located back of the switchboard near the floor, and the water rose above the top of the cases and displaced the oil, causing short circuits which grounded all



OIL DRYER AND FILTER.

the lines and caused some minor burn-outs and breakage of insulators on the oil switches.

Above the flood line everything was wet, apparently by spray from the main stream. The rotors of generators Nos. 1 and 4 continued to revolve for a time, partly submerged in the water, and the insulation of the field and armature coils was cut and scraped in places. The coils on generator No. 2 were also cut and scraped but no injury of this nature was found on No. 3 generator. Aside from this mechanical injury all of the damage to the electrical apparatus is due to moisture.

As soon as the water had drained out of the building the heating plant, which was in working condition, was put into service and

the oil and water were mopped from the floor, walls, and apparatus.

After operating No. 1 exciter generator without load for a time, to dry it out by windage, it was put into service to furnish lights, and generators Nos. 1, 3, and 4 were then put into shape and operated without load during the night, to dry them out by windage.

On Tuesday, arrangements were made with the Standardizing and Testing Department of the Edison Electric Illuminating Company of Boston for drying out and testing the electrical apparatus. The necessary equipment for this work was shipped from Boston by auto truck late in the afternoon, and the work was started the following morning.

A connection was first made with the New England Power Company's line by using portable transformers, oil switch, circuit breaker, and watt-hour meter from the Edison laboratory, so that alternating current would be available for drying and testing the electrical apparatus and for operating the Clinton Sewerage Pumping Station, as the old steam plant at the pumping station, which had been kept in reserve for emergency use, was not operating satisfactorily.

This work was completed Wednesday night, and meantime canvas had been obtained for covering two of the generators which were being dried out by operating them with the armatures short-circuited and a low field excitation, and for the construction of ovens which were heated by means of electricity and used for drying out transformers and other apparatus.

Although openings were provided for drainage of the electric ducts, when they were built into the concrete floor, some of them had become clogged and there was standing water in some of the ducts which made it necessary to disconnect and withdraw the wires in order to dry them out. After the water had been removed from the ducts with swabs, they were dried out by blowing warm air through them. The wires which had also been dried were then replaced and tested.

On February 25, unit No. 3, which had then been dried out and satisfactorily tested, was put into service again. This unit was not in operation on the 17th when the accident occurred, and was uninjured except by moisture.

Arrangements having been made with the Lundin Electric and Machine Company of Boston, for repairing the commutator on exciter No. 2 and the insulation on the field and armature coils of the main generators, this work was begun on February 24 and was completed March 4. On the same day, unit No. 1, which had been dried out and satisfactorily tested, was put into service again, and three days later unit No. 4 was put into service.

Generator No. 2, which could not be operated, was dried with air from the blower and by circulating current from unit No. 1 through the coils while stationary. Satisfactory insulation tests were obtained on this generator on March 10, but it cannot be put into service until the work of repairing the No. 2 turbine, which will probably require at least two months, is completed.

Special electrical equipment used in connection with the repair work includes an electrically operated oil pump and filter for removing water from transformer oil, an electrically operated blower and grids for supplying air for drying purposes, transformers, resistances, and instruments for high-potential testing.

Discussion.

Mr. Carleton E. Davis. Are you prepared, Mr. Foss, to say what was the cause of the accident?

Mr. Foss. All I know is that it apparently followed the pulling of the clutch which releases the wicket gates from the governor control and puts them under hand control. I am inclined to believe that in connection with that the gates closed suddenly, and caused sufficient water ram to break the casting.

Mr. F. H. Hayes. How thick was the casting on the top?

Mr. Foss. The casting varies from 48 in. in diameter down to about 24 in., and the thickness decreases with the diameter. At about the center of the break the thickness was $\frac{15}{16}$ of an inch.

Mr. Hayes. Did it vary as it went through the bottom of the cylinders or the sides? Was it thicker on top than on the sides?

Mr. Foss. The casting increases in thickness at the hub where there are guide vanes inside. There appeared to have been an

internal strain in the iron at one of the vanes where the thick section of metal was located. Aside from that the iron looked very good. I am having some test bars made, to determine the quality of the iron.

MR. ROBERT S. WESTON. How far away were the pieces thrown?

MR. FOSS. One piece was found between generators 1 and 2, about 10 or 15 ft. from the break; and a smaller piece was found out in front of the power station. Apparently the water had drifted them around so that they were not found where they landed.

MR. HAYES. Was there any indication of erosion on the inside of the case?

MR. FOSS. No, none whatever. The original paint is still in good condition.

MR. RICHARD A. HALE. I should like to ask if there is any apprehension in case of the other turbine, in the case of a sudden closing, that a similar accident might happen, and whether any strengthening might be applied.

MR. FOSS. Yes; we are considering that question. Apparently, No. 2 turbine was the same as the others. I might say, however, that from examination of all four, No. 2 appears to be the roughest casting, and perhaps the poorest one. But aside from that they are identical castings, I suppose. And the liability of breaking one of the others by a sudden closing of the gate exists. We are considering making some experiment to determine how many seconds it takes to close the gates with the present setting of the governors, and the possibility of putting a dash pot of some kind on the gate mechanism, so that even when it is thrown off from the governor it will take several seconds to close.

MR. PERCY R. SANDERS. Is the water that operates these generators a part of the supply of the Metropolitan system or waste water?

MR. FOSS. It is a part of the supply.

MR. ——— (Reporter). I should like to ask what the total damage is estimated at.

MR. FOSS. I think that our expenses to date do not exceed $4 000, and we have yet to repair the broken turbine, which will

be the largest single item of expense. If the apparatus stands up as we expect it will after giving it a thorough test, — I do not see why the expense should exceed $9 000 or $10 000 for everything.

Note. Since the paper was presented charts from recording pressure gage installed on turbine No. 4 show a water ram of 5 to 10 pounds in connection with operation under governor control and of 60 pounds when clutch is pulled with a wicket-gate opening of 63 per cent.

The total damage will be less than $8 000.

ENGINES FOR SMALL WATER WORKS.

BY HENRY A. SYMONDS, CIVIL ENGINEER, BOSTON, MASS.

[*Read December 12, 1918.*]

In the design of a plant for pumping the water for a small community, it is usually the case that per capita cost of operating and maintenance is greater than in the large city plants, and it is important that a careful study be made of the relative merits of the different forms of power available, their adaptability, first cost, and efficiency when operating to do the particular work desired.

The educating of the general public to the importance of good water supplies has in recent years brought about a great effort by the citizens themselves, assisted by the health boards and others having to do with the prosperity and health of the communities, to introduce public water systems in the smaller towns.

It is usually the case that strict economy must be practiced in the introduction of these works, and studies relative to first cost have usually been made to bring the cost of the work within the ability of the communities to pay. Not so much attention, however, has been paid to the question of relative efficiency and daily cost of operation, and it frequently occurs that plants are in operation which the citizens of the town, and even the water-works officials themselves, believe to be highly economical, that are the reverse. The difference in cost of operation may be so great as to make it good business to pay a much higher price for an economical unit.

The early use of power for pumping water in the small-town installations was largely by water power or steam, and it is possible that water power is coming back into use for pumping purposes, but probably through the medium of the hydro-electric plants, as it is not common to find good water privileges so located as to be directly available for pumping from the approved sources of water supply.

Steam Pumps.

The use of steam in small plants naturally followed its use in the larger places, and was about the only kind of power available which could be utilized at any and all points.

Steam has been used for many years very efficiently in many small plants, due to the development of the steam pump by expert engineers, and we have to-day numerous examples of small pumping plants of the Dean, Knowles, Blake, Worthington, and other types that have shown good reliability and wonderful endurance, having operated continuously for the entire service of the plant from twenty to thirty years with very little repairs, and are able at this time to continue for an indefinite period in the future.

The common form of the earlier pumps was of the reciprocating plunger or piston type, in which the steam piston was upon the same stem as the water pistons, and this is still the most common form of steam application to pumping.

Steam Turbines.

The development of the centrifugal pump which has now found so wide a field was closely identified with the bringing out of the steam turbine.

The centrifugal pump has been known for a great many years, but for a long time after it was invented the difficulty of getting suitable drive with sufficiently high speed retarded the development of successful operation of this type of pump. The real growth of this pump has occurred in the last ten years, during which time the use of the steam turbine and the electric motor with direct connection to the centrifugal pump have brought up the efficiency of the pump to a relatively high stage. At the present time the use of the steam turbine as applied to pumping water is largely in the large units, and the motor is generally adopted for driving the smaller plants.

The result of the use of steam is, on the whole, satisfactory, but for the small water plants is subject to the objections that the economical pumping machines with boilers are expensive and occupy much space, provision for large storage of coal and adequate

pumping-station buildings are required, all of which add to the first cost of the plant and are aggravated by the fact that licensed engineers are required to operate such a station.

The Ideal Engine.

To-day we consider the ideal small pumping engine that which is economical in first cost, is self contained, i.e., operates from a source of power which is part of the engine or at least located in the same station. It is desirable to have it occupy as small space as is practicable, be simple in operation and not require the services of licensed men, easily repaired, quickly started, using fuel which is readily available at all times, and be capable of producing power at a relatively low unit cost.

Electric Motor.

Many of the conditions of an ideal plant are met by the electric motor and the electrical installation has become more and more common. The advantages are: low first cost; requires little space; low cost of maintenance; no expert supervision; is especially well adapted to drive centrifugal pumps with direct connection, which saves friction loss of gears, and prevents noise; may have automatic control; may operate during periods of low load at central station, thereby getting lower rates; instant starting; as it has no reciprocating parts, can be left to operate without attendance better than any other form of drive. The use of electricity has two serious defects in the average municipal plant; namely, it is not self-contained, but depends upon a line of wires and a power plant, usually at a distance, for its operation. For this reason neither one nor two units in a pumping station operated from the same plant is satisfactory to the insurance authorities, as they rightly claim that an accident to the wire line or the power plant will put both units out of use as quickly as one and leave the town or city in an unprotected condition in case of fire.

There is no exact figure which can be given for the cost of operating by electricity, as the cost of the electricity itself varies very greatly according to the conditions of its generation. The cost

may run to three cents per kilowatt-hour, in a plant where electricity is generated by coal and where the plant is below the size which can be operated at the greatest efficiency or the cost of electricity may be a fraction of a cent per kilowatt-hour, where it is generated by surplus water-power which may be running to waste over the dam for a period of the day or night.

The advocates of the use of motors base their claims of low cost of operation from the fact that attendance may be a minimum and that this is really the large item in operating small water plants. The writer believes that this argument has considerable merit and that the improvement in efficiency brought about recently in the centrifugal pumps and the low cost of the pump and motor, with the advantages above referred to, makes this form of pumping plant a very close competitor and in some cases it will be found to actually be a better business proposition than the other types of pumps and engines in spite of the difference in efficiency. There are many places where electric motors are proper to install for municipal pumping, and the writer has recently overseen the installation of a plant where it is intended to be used as an emergency pumping unit during the renovating of the other pumps and in cases of breakdown or other emergencies. During the past summer it has done the entire pumping for the city.

The following data may be of interest for comparison relative to operation of this unit during July and August, 1918.

Actual test for months of July and August, 1918, of 100-h.p. Westinghouse motor driving Goulds two-stage centrifugal pump, rate 810 gal. per minute, against total head of 301 ft. (Extra charge is made for high price of coal.)

July — Pumped	33 449 850 gal.
Total hours	647½
Kilowatt-hours	52 840
Current cost per 1 000 gal.	2 8/10c.
Total charge	$948.53
August — Pumped	31 409 280 gal.
Total hours	608
Kilowatt hours	45 070
Current cost per 1 000 gal.	2 8/10c.
Total charge	$876.66

If general expense, interest, and all proper costs of operating are considered, the cost per 1 000 gal. water pumped is 7½ cents.

Gasoline Engine.

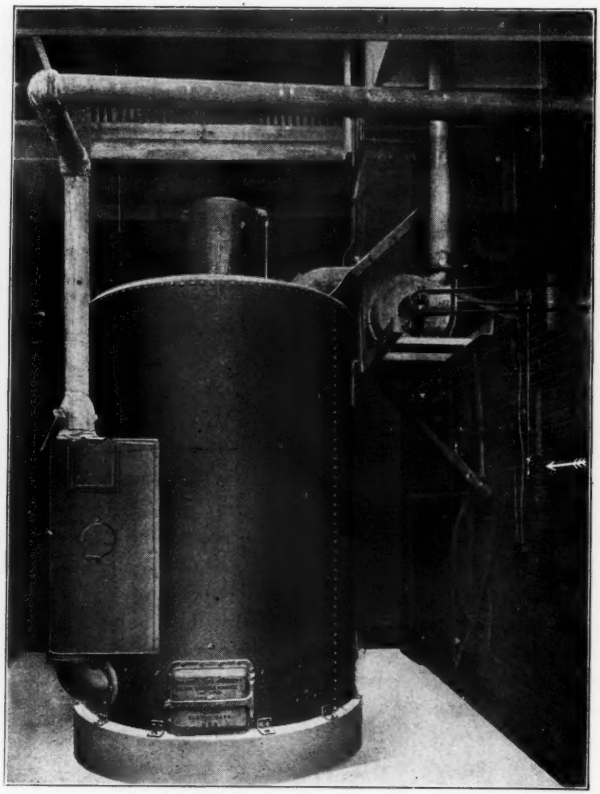
Another form of drive which has been used in some of the small pumping plants is the gasoline engine, and this form of power has practically all the advantages above mentioned except cost of operation, and in this it falls down badly, as it is operated upon a fuel of such high cost as to make the operation per horse-power hour too high for practical purposes in the ordinary municipal water works.

In plants, however, where an emergency unit is wanted and electricity is not available nor desirable for any reason, the gasoline engine may meet the requirements in a satisfactory manner. During the last season the writer had under his supervision the installation of a pumping plant for the Bumkin Island Naval Training Station. This was entirely for fire protection, and salt water only was to be pumped. Cost per horse-power hour was not a consideration for a plant of this kind, which was to be operated only in case of fire and for limbering-up purposes a few minutes a week. This unit consisted of a centrifugal pump driven by a direct connected Van Blerck vertical gasoline engine having a speed of approximately 1 500 r.p.m. The operation of this plant has been a success, and meets the needs of this particular case perfectly. It would be, however, entirely unsuited for a municipal pumping plant operating a number of hours per day continuously, as the fuel cost would be excessive, probably four or five times that of an economical unit.

Produces Gas.

The gas producer as a source of power corresponds to the boiler in a steam plant, and has a great many advantages, and when combined with a proper engine for utilizing the gas to the best advantage may be considered as having most of the requirements of the ideal plant. This form of power has been used for some time, and, so far as the writer has record, with good satisfaction in all

cases. Gas produced in this way may be used in various types of internal-combustion engines with slight modification. A plant of this kind can be installed at reasonable first cost, is self-contained



GAS PRODUCER (GALUSHA).

in so far as the power is generated directly next to the engine itself and operates at a remarkably low cost upon a relatively inexpensive form of coal. The plant takes up more room than some of the other types, and calls for a larger pumping-station space. One

of the latest developments of the gas producer is known as the "Galusha," and while the writer does not wish to appear as an advocate of any particular make of machinery, some of the ideas developed in this producer are of interest relative to small water plants. One of the advantages of this particular style of producer is that it requires but one tank and is very simple in its operation. It has been used to a certain extent for pumping purposes. The period between recharging is three hours. The coal consumption guaranteed is 1 lb. of coal per h.p.-hour. The coal used is usually of the less expensive grades, such as pea, buckwheat, etc., so that the operating cost is usually less than $.005 per h.p.-hour. These producers are made in size from 18 to 350 h.p.

The efficiency of the Galusha gas producer runs from 62 per cent on very light load, to 86 per cent on very heavy load, and the producer will carry an overload of 25 per cent for three continuous hours.

The writer is indebted to Mr. George Hess, of the Nelson Blower and Furnace Company, for following report of test of Smith producer gas engine, and triplex power pump installed for the Lehigh Water Company, Easton, Pa.

Coal used, No. 1 Alden buckwheat.
Duration, 144 hrs.
Head, 208 ft.
Average speed, 46.8 r.p.m., or 3 029 g.p.m.
Speed of engine, 233.9 r.p.m.
Average temperature of starter, 75.2 degrees Fahr.
Efficiency of pump, 88 per cent.
Break h.p. of engine, 296.03.
Total weight of coal fed to producer, 36.152 lb.
Lbs. coal per break h.p.-hour, 93.32.
Lbs. coal per one million gallons water pumped, 1 381.2.
Calorific value of coal fired in B.t.u's per pound, 12 580.
B.t.u. per break h.p.-hour, 9 392.

The size of engine is above that properly considered in this paper, but may be of interest.

Gas producers are used in two smaller plants in the pumping station at Manchester, Mass. The first consists of two 65-h.p gas engines direct connected to two Goulds vertical triplex pumps,

each unit having capacity of 700 g.p.m., operating against a head of 280 ft. The second consists of two 50-h.p. engines direct connected to two Goulds double-acting triplex pumps, having capacity of 530 g.p.m. each against a head of 280 ft.

These units show an efficiency of 150 million foot-pounds per 100 lb. of fuel in daily operation.

The writer would suggest that this form of power be looked into by those contemplating the installation of small municipal plants.

Fuel-Oil Engines.

In the writer's experience, in nine cases out of ten, fuel-oil engines have proven an ideal installation for plants from 25 to 150 h.p., and for this reason it may be proper to give some extra details regarding this engine.

The term "fuel oil" is here used to mean any oil from the heavier crude petroleum up to kerosene. The fuel-oil engine as well as the gas and other forms of explosive engines have been the result of a long series of experiments and developments from the stage where gun powder was exploded in a cylinder to produce power to pump water, up to the present stage where it has met the greatest test of the ages in its use in naval vessels and submarines.

The perfection of this engine has brought the use of the submarine from a cruising radius of 500 miles up to that of 5 000.

Oil engines are now built up to 4 000 h.p.

The writer has at hand a brief history of the development of this engine which may be of some interest.

In 1860 the first step was made when Lenoir, a French engineer, succeeded in converting a steam engine into a gas engine and was able to develop some small engines of this type from one half to 10 h.p. These were of course of very low efficiency, but the principle of the internal-combustion engine had been given a positive start. A little later, another Frenchman, Beau de Rochas, improved the gas engine and brought into use the idea of compression, but was, however, unable to carry on to perfection his ideas, and N. A. Otto, a German, using the idea, developed the "silent motor" in 1877. The so-called "Otto cycle" contained

most of the main principles involved in the later development of internal-combustion engines.

In 1883 Stuart Akroyd, a Scotchman, utilized the Otto principle in an engine using petroleum oil. He was followed by Richard Hornsby, an Englishman, who perfected the engine and manufactured upon a large scale.

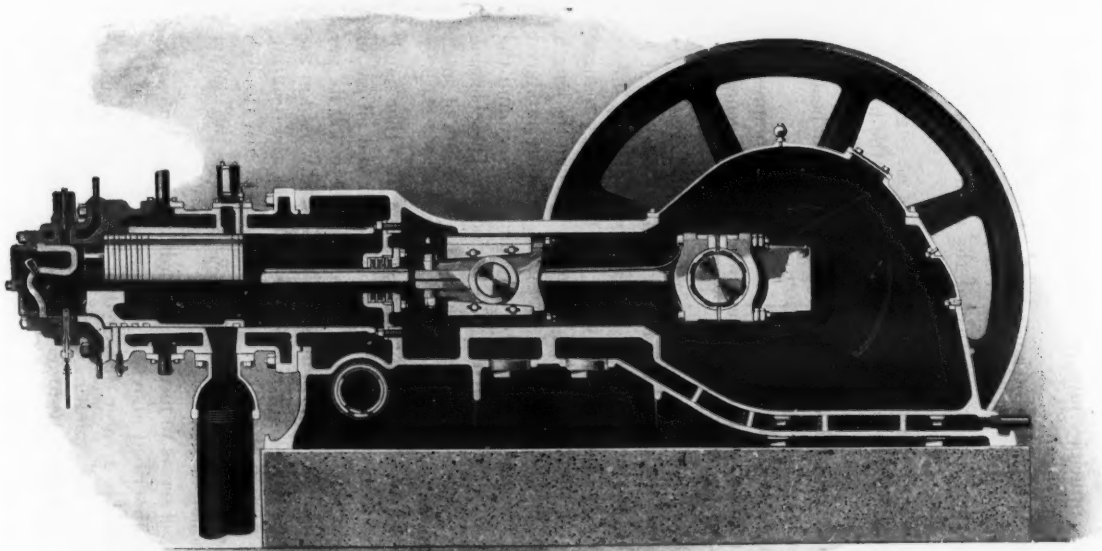
In 1892, Randolph Diesel conceived the idea of an engine running under high compression and able to use as fuel the heaviest crude petroleum or tar oils.

Fuel-oil engines are to-day known under two general heads as Diesel and Semi-Diesel, or surface ignition.

The idea conceived by Diesel is the bringing into compression a mixture of air and oil vapor to a point where heat is generated sufficient to ignite the combination. The compression reached varies from 500 to 1 100 lb. per square inch, but when the proper temperature occurs the gases burn rather than explode, and it is the claim of the producers of the Diesel type that this slower burning conserves the power of the gases and the energy realized is utilized almost entirely in pushing the piston through the length of its stroke. In order to permit of the great pressure produced by this process, the machine must be exceedingly heavy and the great amount of work which is required to perfect the Diesel engine makes them too expensive for the ordinary requirements of small water-supply plants.

The Semi-Diesel, or surface-ignition engine, on the other hand, gets its power by the explosion of a mixture of air and oil gas in the cylinder under the compression of around 200 to 300 lb. per square inch. While part of the energy is undoubtedly used in the shock against the metal of the plunger and cylinder, the resulting thrust produces motion of the piston, which is connected through the crosshead, or directly to a crank shaft which gives the motion to the driving pulley or gear.

The Semi-Diesel seems to meet all the ordinary requirements of the ideal engine described above, and while the first cost of this engine is considerably greater than that of the gasoline engine or the electric motor, the operating costs are so low that they outweigh in most cases the advantages of low first cost of the other machines.



Section of Fuel-Oil Engine (Bessemer).

For many years we have heard arguments by the advocates of the two- and four-cycle engine tending to prove that one or the other of these types was much superior and more economical in its operation than the other. In view of the claims and counter claims, the writer has felt somewhat disturbed that he has not been able after considerable investigation to determine positively which is the decidedly better machine, after having used first one machine and then another in all kinds of water-works installations, first that one was superior, then that the other showed more merit, and he must confess at this time that he does not know which is actually the more economical machine to operate.

The following table, while not a true comparison, as the two sets of machines are of different sizes, and operate under very different conditions, yet the quantities here may be of some value in showing actual costs of operating under normal conditions.

Actual unit costs of operating two-cycle and four-cycle engines, June 30, 1917, to June 30, 1918:

	Gal. Pumped per M.	Total Head.	Gal. Water Pumped.	Gal. Fuel Oil Used.	Gal. Oil per 1,000 Gal. Water.	H.P. Used.	Gal. Oil per H.P.-Hr.	Price per Gal. Oil.	Cost per H.P.-Hr.
2-cycle .	250	307	46 383 818	8 841	.19	24.2	.12	$0.084	$0.0101
4-cycle .	691	188	60 658 650	6 472	.107	46	.108	.091	.0098

The data in this table are taken from the logs of the pumping stations and are subject to more or less inaccuracies, but are probably very close to the true amounts, and in so far as this one comparison goes there is a striking similarity in the cost of operation. If the same price of oil is used in both cases the difference will be more in favor of the larger four-cycle engine, but on the other hand the larger machine has a slight advantage because of size.

To describe the action of the two-cycle engine briefly: After the explosion stroke is completed, the exhaust port is un-

covered by the return of the piston, and the ejection of the burnt gases takes place in connection with the injection of the new gases.

The four-cycle engine accomplishes the same purpose as the two-cycle, but does it in four strokes of the piston instead of two. There are several installations in New England where both the two- and four-cycle engines are used together, but the writer is not able to learn from the operators of these plants that an appreciable variation in the merits of one over the other is apparent.

The ignition is brought about in the Semi-Diesel engine by a hot cylinder head or tube which is first heated to the proper temperature by a blow torch and is afterwards kept at a red heat by the explosions.

It has been the common practice to inject water into the cylinder for the purpose of promoting proper combustion. This feature has been eliminated in the newer types of the Fairbanks-Morse engines, which are now manufactured upon what is designated as the dry type. It is claimed by the manufacturers that the effect of the water injection was to form oxide of iron in the cylinders, which rapidly wore out the cylinders and plungers.

It will be interesting to note the action of the dry type relative to this feature.

In the types which are considered as small pumping outfits, designed to pump the water for communities of from 1 000 to 10 000 inhabitants, the engines required ranged from 25 to 150 h.p., but in the writer's opinion there is a large field for a still larger oil engine, and there are some machines now being produced that show wonderful efficiency in operation. They are of the Semi-Diesel type but are able to operate on the poorest grade of fuel oil and even tar products which have to be heated before it is possible to get them into the cylinders. The oil used runs as low as eighteen degrees Beaumé, while in the smaller machines, that is, below 60 h.p., the writer knows of good results with oil heavier than twenty-six degrees Beaumé, and with 25-to 35-h.p. engines kerosene or light oils of that grade have seemed to give the most satisfactory results.

Pre-war prices ranged from 2 cents to 7 cents for the various grades.

The ordinary time of starting with fuel oil is from twelve to

eighteen minutes, but engines of this type may be equipped with apparatus which permits of instant starting by electric ignition and gasoline, turning on the fuel oil after a few minutes, without interruption of the operation of the engine. This latter contrivance is of especial value where but little storage of water is possible and pumps have to be operated in case of fire, as the delay in heating the cylinder head may be serious if the supply of water is not available.

It is claimed by the advocates of the electric motor in comparison, that the motor requires little attendance, while the oil engine calls for constant supervision. This claim is not entirely substantiated in practice, for many of the oil plants are operating for long periods of time without attendance. With a suitable system of lubrication and proper safeguards, there is undoubtedly a great saving in most cases by permitting the plants to operate without attendance. It is true that breaks will occur and lubrication will fail at times, but the resulting damage is insignificant compared with the cost of wages for constant attendance.

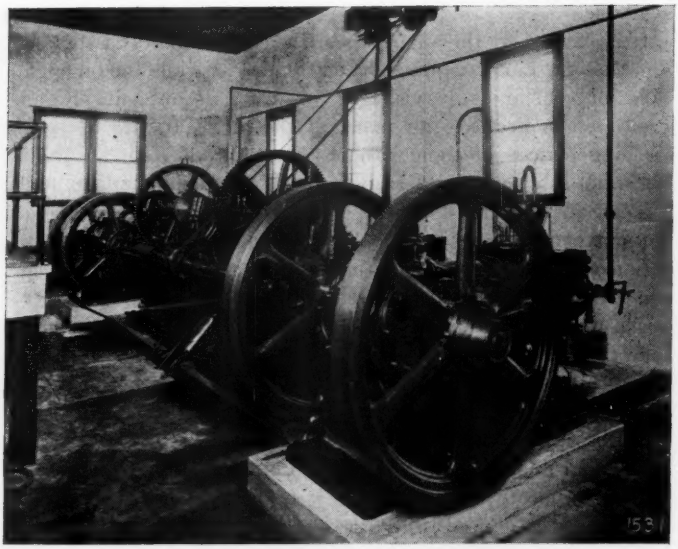
This of course assumes that there are duplicate units which will take care of any fire hazard if repairs are necessary. It should also be considered that constant attendance does not eliminate many of the breakdowns.

Perhaps the most satisfactory combination that can be installed for a small pumping plant for general municipal needs is made up of two duplicate units of which it is probable that the fuel-oil engine meets the needs fully as well as any other drive which has been developed up to this time.

A convenient arrangement, which the writer has found very effective, is to place two vertical Triplex pumps geared to two pinions running upon the same jackshaft, the jackshaft being in the line of the main shaft of the fuel-oil engines which are placed at each end of the pumps. The connection between the engine shaft and jackshaft is made by clutches which permit either engine to operate either pump. This establishes a system which can meet most any condition that is liable to occur in the way of breakdowns without interrupting the service.

Another combination which is satisfactory and meets the requirements of the insurance authorities with a little saving in first

cost is where one or two pumps are driven by a fuel-oil engine and an electric motor so arranged as to be thrown into operation alternately as desired. The low cost of the motor saves something on the first installation and the daily operation can be taken care of largely with the engine while the motor is used for the emergency unit.



PUMPING PLANT, MEDWAY, MASS., WATER WORKS.
(Meitz & Weiss Oil Engines.)

One advantage which is of considerable importance in some cases that steam machines have over most of the other types is in the varying of speed in operation. The speed in the electric motor and of the internal-combustion engines is variable only to a small extent except by change gears or belt pulleys, and it is sometimes necessary to pump to waste or through a bypass back into the suction, an uneconomical process, in order to keep the rate of delivery as desired.

It is possible that one of the triumphs of the future engineer is

the invention of an internal-combustion engine which will have the same flexibility as to speed of operation as the steam engine.

The writer had occasion, a short time ago, to make a comparison of different types of pumping plants to determine which plant would best meet the needs of a community. In connection with this, the results of investigation of different units were tabulated and are here given.

The figures in this table are not, of course, to be considered as exact costs, either of operation or first cost, but are the results obtained by using quotations and guaranteed efficiencies by the manufacturers of the different lines of machinery. The estimates are subject to all kinds of variation but are intended to give a fair average ample cost of machines suitable to the particular work to be done.

These figures were also taken before the extreme rise of prices which has occurred since we entered the war, and while they are far above the averages of five years ago it is probable that they are nearer what we may expect in the next few years than pre-war prices. In general, the figures given are intended as a comparison, and the writer believes give a general idea of the comparative costs.

The question of size of the pumping engine is really a problem of the capacity of the pump except to provide sufficient margin of power to drive the pump under all conditions of loads which may be brought upon it. It is usually the case that the rating given for motors and engines by the various manufacturers contains sufficient margin of safety to be able to meet all demands, even if the load slightly exceeds that which was originally estimated. The proper size of plant is a matter which has been reviewed frequently, but there seems to have been some variation of opinion as to the most satisfactory capacities for various small plants. In the writer's experience, he has found danger of underestimating the convenient size and has had the most satisfactory results where the plant has been designed to pump the estimated daily consumption at the start in about six to seven hours, as the inevitable growth of the plant and increase in consumption will lengthen the time of operation. This gives a margin to provide for the period of pumping which might otherwise require more than one shift.

TABLE 1.

1 500 G.P.M., 250 Ft. Total Head, Operating 300 Days per Year, Nine Hours per Day. Theoretical H.P. 94.7.

Pump.	Drive.	Per Cent Eff. Pump.	H.P. Required.	Cost of Fuel per H.P.-Hr.	Total Fuel Cost.		Estimated Cost of Plant.	Remarks.
					Per Hour.	Per 300 Days.		
Vert. triplex	Fuel-oil engine	85	112	$0.004	$0.498	$1 209.60	$17 188.60	Guarantee — 1 h.p. for .55 lb. fuel oil per hour. Price fuel oil, 4c. per. gal.
Centrifugal	Fuel-oil engine	71	134	.004	.536	1 547.20	16 342.70	
Vert. triplex	Steam turbine	85	112	.0075	.840	2 268.00	13 657.00	Coal at $6.00 per ton (2 000 lb.)
Centrifugal	Steam turbine	71	134	.0075	1.005	2 713.50	9 957.00	
Vert. triplex	Electric motor	76	125	.0124	1.55	4 185.00	11 115.60	Efficiency is combined pump and motor. Electricity cost, $\frac{9}{10}$c. per h.p.-hour plus "service charge" of 77c. per h.p., based upon max. h.p. in use, per month.
Centrifugal	Electric motor	64	148	.0124	1.84	4 968.00	6 248.00	
Cross compound, fly wheel, steam pumping engine						1 350.00	17 000.00	
Compound-Duplex-Deane steam pump — (Original plant). Rate about 700 g.p.m.						2 725.61		Actual figures of present cost. Rate of pumping about 700 g.p.m.

No fixed rule can be made, however, which will meet all cases as the rate of growth is widely different.

No study of power engineering can be made without awakening the greatest admiration for the wonderful work which has been done, first in the attempt to find some way of producing motion through machinery, and, in the gradual evolution of power production through the development of the steam engines, the internal-combustion engines, and the electric motor. The progress has been wonderfully rapid, and seems to be accelerated as time goes on in discovering and putting into operation new methods of getting greater power and greater efficiency. The discoveries of the last few years as to the great volume of oil to be extracted from the rocks of vast ranges of mountains in Wyoming and adjoining states give us more courage to continue development of the oil engine, as it is probable that fuel for its operation can be found in sufficient amounts to take care of the world's consumption, although rapidly increasing, far into the future.

Discussion.

President Davis. This is an exceedingly interesting and instructive paper. I want to ask Mr. Symonds one question. I notice one of the evident advantages of an internal-combustion engine is the fact that a licensed engineer is not necessary to run it. I wondered whether it took, in general, a higher grade of man than is necessary in a steam-operated pump. And, Mr. Symonds, what your experience has been in the way of repairs and maintenance, — whether repairs have been easily and economically made after an accident, or whether you have had the experience that some of us have had when our automobiles got into trouble.

Mr. Symonds. As regards the class of men that operate engines, we employ men who have good general mechanical ability, not licensed men. In small water-works plants it is often desirable to have an operating engineer who is also a good business man and can look after the general business of the department or company and frequently one man is able to do all the

local work. It is of advantage not to require licensed men, because some of the men employed in this work are excellent business men and have fair mechanical ability but would not be able to secure licenses for operating steam plants, although entirely capable of operating internal-combustion engines.

As regards the question of repairs, my experience has been that in general the fuel-oil engines have stood up without a serious amount of repair. There are more parts in an oil than in a steam engine, and consequently more complications, but in most plants the repair costs have been very low.

PRESIDENT DAVIS. Has there ever been any trouble in getting it done, or finding anybody who could do it?

MR. SYMONDS. We have not had any trouble of that kind. I have occasionally had emergency calls, to get repair men instantly because of some peculiar action of the engine, but they never have materialized as serious troubles. Usually, as in the case of the automobile engine, some insignificant feature was the cause of the whole trouble, which, when discovered, was very readily corrected.

MR. FRANK L. FULLER.* I should like to ask Mr. Symonds if he has any record of the cost per horse-power hour for the different fuels which he has spoken of with engines of this moderate size. For instance, electric current, fuel oil, and steam. How they would compare.

MR. SYMONDS. I think the table presented, which estimated the yearly costs, furnishes such a comparison. There are an infinite number of conditions, and unless you take one set of conditions and figure it out, taking identically the same basis, you do not get a perfect comparison. For the small machines, purely on the basis of fuel costs, the producer-gas engine operates at about the lowest cost of any type which has come to my attention. Wherever we have made comparisons the cost per horse-power hour for producer-gas engines has been very low.

MR. FULLER. Well, from your knowledge, experience, and records, probably such a table as I speak of could be figured out. That is, from your records of a year's running the cost per

* Civil Engineer, Boston, Mass.

horse-power hour for any particular plant could be figured out fairly accurately, or perhaps very accurately.

MR. SYMONDS. Yes. Such a comparison, while only approximate, is made in the paper presented.

MR. CREED FULTON.* What did you have as the fuel cost per horse-power hour in the table that you used?

MR. SAMUEL A. AGNEW.† I understood that that table showed the cost to be about .459, meaning almost a half cent per horse-power hour, as I recollect those figures. That is what they generally figure.

MR. SYMONDS. Yes, the table gives as a comparison about a half cent — .4 — per horse-power hour for fuel-oil drive; about twice as great for the steam turbine, and about three times as great for the electric motor in that particular case.

MR. FULLER. I think, as I remember it, our pumping plant at Wellesley showed a price, five or six years ago, — before the price of coal increased as it has, — of about a half a cent per horse-power hour. Of course it would be more now.

MR. G. HOWARD HAYES.‡ Perhaps I can add one or two figures to those of Mr. Symonds. We have a plant which was installed about four years ago which compares very closely as to pumping conditions with the centrifugal pump of which Mr. Symonds spoke. This is a 1 000-gal. Triplex pump driven by chain from a 100-h.p. electric motor. The average head is about 106 lb. Fairly close records have been kept of this pump. Just about a year after it was officially tested it was tested again to see how it was maintaining its efficiency. The official test showed an efficiency of slightly over 77 per cent. That is, taking the water pumped into the standpipe against a head of from 102 lb. to 112 lb., and the electricity consumed as shown by the meter.

The second test showed practically the same, that is, 77 per cent., or a little more. I have some of these figures here. The average head was 106 lb. The pump ran 8 840 revolutions, and in doing so pumped 216 796 gal. and used 220 kilowatt-hours of

* Goulds Pump Co.
† Superintendent Water Works, Scituate, Mass.
‡ F. H. Hayes Machinery Co.

electricity. That place is obtaining its electricity at a very small rate. It is only 1.8 cents per kilowatt-hour at night. That gives a cost per thousand gallons pumped of only 1.15 cents, which compares with the centrifugal unit which Mr. Symonds mentioned of 2.8 cents.

A test was also conducted a year after that, the third year, which showed practically the same results. I hope we shall be able to have another test this year to show how it still holds up; but as a general thing I think I can say that the Triplex pump will always justify its additional cost over the centrifugal where economy of operation is the primary item. Do not understand me to say that a centrifugal pump is not a proper pump under some circumstances — it is, but especially where large volumes of water and low heads are encountered. Very seldom will the centrifugal pump be the best pump to use on water works, especially on variable heads as pumping into standpipes. I am not speaking from a prejudiced point of view in favor of the Triplex: we are interested in both — have both of them — and the Triplex pump will justify its extra cost. Also, if we turn to the oil engine we generally find the oil engine will justify its cost over the motor.

In the case of the oil engine we can generally assume that the oil engine will show a duty per gallon of fuel used — that is, actually burned in the engine — of from 14 000 000 to 15 000 000. Sometimes it will run a little less and sometimes it will run more. I know of one case where the average duty per gallon is 18 000 000, and that in a place which would compare very favorably with the small plant Mr. Symonds mentioned.

Possibly the people in this place are especially favored with their operator, because I really think he knows more about the engine than the people who built it. It is an exceptional case so far as the man who runs it is concerned. But on the basis of 14 million or 15 million duty for fuel oil I think you will find that the average cost of operation of an oil engine is about one-third of the average cost of electric operation of the same pump with what is ordinarily called upon to be paid for electricity.

MR. F. H. HAYES.* Mr. President, if I may be permitted, I should like to answer Mr. Fuller. Mr. Fuller's question was in

* F. H. Hayes Machinery Co.

regard to the cost per horse-power hour. If you can buy oil for eight cents a gallon, it means a cent per horse-power hour; if you can bu it for four cents it is one-half cent per horse-power hour; if you buy it for twelve cents it is one and one-half cents per horse-power hour. You can use oil at 6 cents per gallon. To meet it in electricity you have to buy it for less than one-half cent per kilowatt hour. Those are things that we are in a position to prove, as we have had to prove them in the past.

I am very glad that Mr. Symonds has brought up this subject that he has. I have been trying it for twenty-five years. Some of the gentlemen who are here are using machines that were put up many years ago. There was one installed in Cohasset, probably the first one that was ever applied to a pumping engine. That was a Hornsby-Akroyd engine. It is now in operation, but it is a good deal like the old lady's stocking. There are a good many parts of it that have been renewed but the fly-wheels are there and running to-day. That particular one I think runs more in the twenty-four hours and in the year round than some of the others, for the reason that when they start it up they never stop it unless it stops itself. An oil engine is wiser than a man; it will stop if it is overloaded, and a man won't. There have been so many different kinds of this combustion engine brought before the public that it has been necessary to study it. The first was the Otto. It uses gasoline beautifully. There are a lot of them that will use gasoline beautifully. Then they went from that to kerosene. Then they go from that to a cheaper fuel. There are engines that have been built for using a cheaper oil. There are engines that are sold for the cheaper oil that work better on kerosene oil and on gasoline. I imagine that some of the gentlemen who are here know that I am telling that which is so. The condition surrounding the fuel oil is that there are more B.t.u's in it. If you go from that to kerosene oil, that which is called " solar " oil, there are some of the heat units taken from it. When you go from solar oil to kerosene you lose some of the B.t.u's, and when you go from kerosene to gasoline you lose some of the B.t.u's. And also in the gasoline, the evaporation of the gasoline itself does not produce power but it does cost you money and is a charge against the plant.

In regard to the use of an engine without care — that is, care all the time — it may be answered in this way. There are three engines in a particular place, and there is a standpipe up on a hill. The gentleman goes there at night and sees what his pressure is, judges how long it will have to run to fill it up, fills his fuel tank with oil, and when that oil is run out the tank is full and the engine stops. That same engine I have known to run four weeks without a stop. So that the record of the oil engine used in connection with the small pumping plant is worthy of the consideration of you all.

Mr. Bertram Brewer.* We have no bias toward any particular type of pumping plant, but there are certain advantages in electric pump operation, especially in a small plant, which cannot be gainsaid.

Of course the cost of power is high, especially in comparison with an oil engine, but past experience indicates that electric power is more likely to decrease than increase in cost in normal times. The electric plant can be operated absolutely automatically with a minimum of risk to the machinery, and the depreciation of a well-made motor is not a big item. Where frequent starting and stopping are necessary, automatic control, by cutting out practically all labor expense, puts the motor in a class by itself. A stand-by unit, preferably of the oil-engine type, furnishes a reliable alternative power in case of a breakdown, and makes the second factor in a remarkably good combination when the odor and noise are not objectionable.

Attention is called to the fact that the towns of Ashland and Amesbury have recently substituted electricity where an oil engine had been used. The authorities at Ashland concluded that they could more readily secure the greater flexibility which they desired from the motor. Longer life and more years of service are expected. This reminds us that in certain cases flexibility outweighs every other consideration, as it is often necessary in some plants to secure every last gallon of potable water in time of drought. As there is every prospect, therefore, of more and more automatic pumping and in larger and still larger units, and

*Assistant Engineer, State Department of Health.

since the saving of labor is so vital a matter, the following notes bearing especially on the details of automatic pumping by electricity may be of use to some one who has such a plant to design.

Many small electric pumping plants are operated more or less automatically to-day, whereas ten years ago when the writer designed and built one they were almost unknown, at least in municipal practice. In this particular case, which was a sewage-receiving well in an outlying district, frequent starting and stopping were necessary and cleanliness and quiet were indispensable. A noisy, bad-smelling exhaust was prohibitive.

The important features to be considered in automatic pumping with electricity may be summarized under the following five heads:

1st. Proper automatic acceleration of the motor to its full load.

2d. Protection of the motor against a sudden dangerous diminution of power.

3d. Protection against overload.

4th. Precautions respecting temperature changes and humidity.

5th. Provision for keeping the pumps and their connections free from air pockets.

Just a word of explanation concerning each of these five points:

1. *Efficient Automatic Starters.* Starters that reliably provide for automatic acceleration of those motors large enough to require starting torques less than full load torques have been on the market for some time and are satisfactory. This feature may be said to be well in hand.

2. *Protection against Fall in Voltage.* In one plant which has been operated for ten years and was installed without automatic protection against fall in voltage, a failure or rather loss in current has twice caused the motor to burn out. While the motor did not receive enough current to revolve and ventilate it, it did receive enough to heat it up sufficiently to melt the windings. Each time, however, the power company acknowledged the fault and paid for the repairs, as it was due to grounding of wires in a storm in one case and careless handling by the power company's men in the other. In recent years sudden fall in voltage has also been met by appropriate devices that shunt off the current automatically.

3. *Overload Protection.* Of course fuses have always been used

to guard against overload, but they have not always proved sufficiently flexible. We understand, however, that the latest type of starters are supplied with a self-contained and more satisfactory overload protection.

4. *Precautions against Meteorological Conditions.* The question of heating the building containing the plant has always been an important one. Starters can be obtained to control the pumping from an open well that work in all kinds of weather. Care must be taken, however, to place pumps and water-filled pipes well below frost line. Arrangement of the wires that control the float and starter must be such as to allow for their possible contraction or expansion. Care must also be taken to prevent the twisting of these wires in cold weather. Furthermore, a kind of oil that will not congeal at low temperature must be used.

Plants in a closed pressure system must be continually maintained above the freezing point by artificial heat. Considerations of humidity point always to a distinct physical isolation of that part of the plant that controls and furnishes the power, as the best design, though it has not always been found necessary.

5. *Air.* The fifth and last difficulty, — that of air in the water line, — unless carefully guarded against, will upset all plans for remote control.

Finally we present a list of some of the municipalities near Boston where there are pumping plants operated by electricity. Some of them are more or less automatically controlled:

Water-Works Systems.	*Sewer Systems.*
Weston.	Newton.
Ashland.	Waltham.
Lawrence.	Clinton.
Newton.	Worcester.
Lynn.	Boston.
Norwood.	Hudson.
Fall River.	Milford.
Wellesley.	Andover.
	Maynard.
	Norwood.

MR. FULLER. There is a little plant at West Groton, Mass., where there is a motor-driven pump which is started automatically

by an arrangement whereby a clock turns the current on and off, so that by an adjustment the pump is started, we will say, at seven o'clock in the morning, and shut off according to the demand for the water. I understand this has always worked very well.

PRESIDENT DAVIS. I want to ask Mr. Hayes whether the oil engine has been used to any extent as auxiliaries at big stations.

MR. F. H. HAYES. I do not know of any around here, but there is no reason why it should not. Any of the steam-driven units in the pumping stations which will operate any of the vertical Triplex pumps will take 40 lb. of steam per horse-power hour, and that runs up on the coal bill pretty well. Now, you take an engine that will run that same auxiliary. It will produce its horse-power per pint of oil per horse-power hour. That is on the smaller ones. When you use the larger ones you get down to .75 of a pint per horse-power hour. Does that answer your question?

PRESIDENT DAVIS. Yes.

MR. F. H. HAYES. I might answer the other question which you asked Mr. Symonds, in regard to reliability. That particular engine that he showed us on the slide — it is a fact that that particular engine, of 80 horse-power, ran for one year and was not stopped but twenty minutes. So that the repair part of it was not much.

MR. A. O. DOANE.* When making plans for the smaller stations for the Metropolitan supply we investigated all of the types of pumps which have been mentioned here this afternoon. Some of the things which we went into may be of some interest. One of the points that I have not heard mentioned here in connection with the oil engines, gas engines, and producer-gas engines, is their applicability to stations which are situated in residential neighborhoods. We have some small stations situated in such localities, with particular neighbors, and they are pretty fussy about what goes on in connection with the smells and noises, particularly in the night. And our investigation of producer-gas and oil engines showed that it was very difficult, if not impossible,

* Division Engineer, Metropolitan Water Works.

to so reduce the noise from the exhaust by a muffler, that it would not be objectionable to near neighbors.

There is another objectionable feature in producer-gas plants, and that is a strong smell of gas apparent at all of the plants, even in spite of steps which have been taken to prevent it. It seems to me it must be very disagreeable and injurious to the help, and in the summer time the neighbors might smell considerably more gas than they wanted to.

We have in one district a plant of less than three million capacity, and when we took the matter of electric operation up with the Edison Company they were unable to show us any economy over the steam operation, even when compared with a small direct-acting pump, which we all know is rather wasteful in the use of steam, unless the attendance could be cut right down to the bone, — in fact, almost to automatic operation. As our stations are the main reliance for fire protection and some of our standpipes and reservoirs are located where it would make considerable trouble and cause damage if they overflowed, we did not feel justified in taking the risk of automatic operation.

There is also a danger in electrical operation, even if you have duplicate units, that something may happen to the overhead transmission lines or to the generating plant. I know of a case not far from Boston where an electric pump operated a drainage system by pumping out a sump too low to drain by gravity to the sewer. One day a very heavy storm came, and a flash of lightning struck the power station, knocking out that particular section that fed this place. The consequence was that the pumps stopped, the drains overflowed, and water got into the basements causing several thousand dollars' worth of damage to goods.

Undoubtedly the electric motor for small plants, where the responsibility is not too great, is almost the ideal thing. We have one pumping sewage to filter beds which is semi-automatic. It is started by an attendant at the filter beds on his way to work, and when the sewage is pumped down in the collecting well the pump automatically stops. In this particular case entire automatic operation was neither necessary nor desirable, for it was better to put the sewage on to the beds when the attendant could be there to see that it was properly distributed.

In regard to the question that was just brought up about auxiliaries in steam plants. In the case of most water-works plants, condensing-steam machinery is employed and in the steam-pumping station, especially if auxiliaries directly connected to the main pumps are used, it is generally pretty hard to get enough waste steam or exhaust steam of high temperature to heat the boiler-feed water, which condition would be aggravated by using oil engines, which would not furnish any ource of heat except possibly a little from the cooling water.

Mr. F. H. Hayes. May I answer Mr. Doane in regard to the heating of the building by an oil engine? It is possible and it is done. I have also in mind another place where in the installation of a small water-works plant in Maine they put in a steam pump with a boiler. They put in a boiler and an oil engine. The conditions surrounding were such that they could not get wood to fire the boiler, and they put up electric wires through the woods with the result that the wind came and blew down the wires, so they started up the oil engine and it has been running ever since.

Mr. Reeves J. Newsom.* I have had some experience in comparison of oil engines with motor-driven units, and in two cases in particular the motor-driven unit was the more desirable. These plants were for the city of Lynn, and while they are considerably larger than those described in Mr. Symonds' paper, the one being 15 million gallons a day and the other 20 million, there are two considerations which entered into these problems independent of the size of the unit. Both of these plants — one is in operation and the other is only proposed — are for use of the supply into the system. That is, the pumping of water from the rivers into the reservoir. And in both cases the pumping takes place in about three months in the year. And under those circumstances the fact that the oil-engine installation is considerably larger in its first cost made the motor-driven unit more desirable even had it operated at considerably higher cost. The operation, of course, only went on for three months, and the interest charges on the first investment went on for the twelve months. Then both of these plants were more or less isolated, being out on the

* Superintendent Water Works, Lynn, Mass.

reservoir system, and it was desirable, if possible, to have units which we could operate with a very low class of attendants. We have operated the one plant and will the other with men who are only watchmen, patrolmen on the reservoir. I do not think that it would be advisable to intrust the operation of an oil engine to this type of attendant.

PRESIDENT DAVIS. Do you have to pay stand-by charges on your electric current? You said you operated for three months in the year; do you have to pay stand-by charges for the remaining nine?

MR. NEWSOM. No; we have a minimum charge on the one station that is in operation of $1 000 a year, but it only requires fifteen days' pumping to eat up this minimum charge, and it must be used for pumping at least that amount. So that there is no occasion in our case for us to pay a minimum charge for which we get nothing.

MR. T. G. HAZARD, JR.* There is another point in connection with this subject that has been of a little interest to me, and that is the question of whether the hammer in the pipes is the result of the use of a one-cylinder oil engine. I have operated a couple of these 25-h.p. internal-combustion engines, and we have had some trouble with water hammer since they have been in operation. I would like to ask if anybody else has had that same trouble. Most everybody remembers a time about ten years ago when the first automobiles were in practical use, that it was a choice between a steam engine and a one-cylinder gasoline engine, and any one who has tried the two types remembers the different feeling in riding with a very smooth-running steam engine and a very jerky one-cylinder gas engine. I have found that the pulsations of the pump are apparent at a very great distance from the pumping station where a one-cylinder, internal-combustion engine is used.

PRESIDENT DAVIS. What kind of a pump have you?

MR. HAZARD. Triplex.

MR. SYMONDS. In connection with the subject of water hammer, several cases have come to my attention, but in no instance have we been able to hold the engine responsible for it.

* Civil Engineer, Narragansett Pier, R. I.

I have in mind three cases; the first of these caused extreme vibration in the pipes in a factory, and in dwelling-houses in this particular section. The water supply in this case was gravity, and the particular section where the trouble occurred was under about 110 lb. pressure. It was finally traced to an old duplex-boiler feed pump, which was badly out of repair, and was sucking air. This pump was pumping directly from the mains. The trouble stopped as soon as the pump was put in order.

The second case was also on a gravity system, and has never been fully explained so far as I know. Continuous hammering occurred at the end of a long 8-in. pipe about a mile from the reservoir. We could find no pump connected with this pipe. I suggested the use of air chambers as a possible remedy, and have not heard from the case for some time, so this may have solved the difficulty.

The third case is on a pumping system, about one mile from the pumping station on one of a series of side streets leading off from the main line. The plumbing in one house at the end of this line has continuous vibration when the pump is operating. This street has been practically shut off. In this case the pumping is by a Triplex pump driven by a De La Vergne single-cylinder engine. It is a strange fact, however, that the vibration occurs in no other point in the system, although there are numerous streets similarly situated, and it is also practically all at one house.

Mr. F. H. Hayes. It is suggested that the cause of the water hammer can't be laid to the oil engine, but it is a possible thing that the water cylinders of the pump do not fill full. If they do not fill full they will water hammer.

Mr. Fuller. At Marblehead, some years ago, there was a tremendous amount of water hammer in the upper portion of the old Forest River Lead Works building. It was thought perhaps there was air in the pipes and every effort was made to remove any air that might be there. I do not know whether the trouble was finally eradicated or not. There was one other house in Marblehead where they had a good deal of trouble from water hammer, but I do not know how that ended. That was from a steam pump that was located not very far from Forest River. None of the engines which have been spoken about were

used. At Wellesley there is one particular place on a side street where, when we changed from the regular pumping engine, which was one of the original duplex pumps, there was trouble of this kind. When we changed back again to the regular pumping engines the trouble seemed to stop. It has always been a mystery what produced the water hammer in those places which were off the water main. I think there is a good deal of difficulty about removing those causes.

Mr. C. W. Fulton. I happened to be the goat, a few years ago, in looking up troubles. I am rather inclined to think, in the case of this oil-driven engine pump, the trouble is probably in the suction side of the pump. Sometimes the pump won't take its suction uniformly. And, as Mr. Hayes said a few minutes ago, the cylinders on the upper stroke of a single-action pump won't fill completely, and they hit on a partly filled cylinder and you would think the pump was going off the foundation. I think in this case the water hammer may have been due to that because of poor regulation on the part of the engineer.

Mr. A. O. Doane. We had a case where there was no trouble whatever in the station when operating a direct-acting pump; it seemed to be going along as smoothly as possible, yet there was considerable noise in certain parts of the pipe system, and it seemed to be due to running the pump at certain speeds. At one speed it would be very much worse than at another. And we had never been able to find any very satisfactory remedy for that condition excepting to be careful to run the pump at a speed which would make the least trouble. But as it is a reserve pump it does not very often trouble us anyway.

The answer to that certainly is the centrifugal. The centrifugal does not cause any shock, so far as I know. And furthermore, I think that if you have occasion to pump into the mains directly, without any standpipe, reservoir, or other outlet except the services, the centrifugal is nearly the ideal machine, for it is automatically regulated. That is, if the centrifugal goes at uniform speed and the pressure drops when a big draft of water comes, the centrifugal automatically pumps more water as the head drops. And the converse is true, — if the pressure runs up the centrifugal pumps less water. In this way it acts as an automatic regulator,

even when running with a constant speed motor. It would not do any harm if the discharge outlet was closed altogether.

PRESIDENT DAVIS. Heat it up?

MR. DOANE. Yes, it would heat up but would probably do no serious damage to the pump.

MR. LEONARD METCALF.* I have been very much interested in this excellent paper of Mr. Symonds and the admirable discussion which we have had after it, because it serves to bring home the complexity of the problem of the small pumping station. I think in many ways it is a much more difficult problem than that of the big pumping station, because you have not the financial resources with which to work.

One can't review the work of one of our old and valued members — Mr. Freeman C. Coffin — without having one's admiration aroused by what he did in the development of these small pumping stations.

I am sorry that Mr. Agnew is not here, because he might add a word in regard to the situation at Scituate. But there are various papers in our JOURNAL which perhaps have covered that ground fairly well; and there are other members, I think, who have become very familiar with the Hornsby-Akroyd engine, as it has been used at a number of other stations. The main lesson which it teaches, as I see it, is the lesson of comparative reliability in the case of a small water-works plant, even though the attendance of labor — that is, the amount of labor — expended on the plant be reduced to the minimum.

I have been very much surprised, in going over the records of the Scituate Water Company, to see how cheaply it has operated its works, because, though there are three pumping stations (one of them only is operated during the winter season ordinarily, and the other two, during the summer season, when the summer colony is there and increases the population of the town from about two thousand to about thirteen thousand people), nevertheless they are able to operate the stations with very little labor. The pump is oiled, started, and taken care of in the morning, the key is turned in the door, and the station is allowed to run itself until the oil supply gives out.

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* Metcalf & Eddy, Boston, Mass.

That brings home to us the importance of reliability, and I rise merely to add a little emphasis to the comments of several other speakers in regard to the subject of reliability, because, after all, the operation of the water works is a function touching the public interest. If the works are corporately owned, and fail for even a couple of days to render service, they may undo the work of five or ten years in the building up of the public good-will. And I might say that in the case of the municipal works, of course, any serious trouble of that sort usually results in a change of administration.

It brings home to us, then, this fact, that the reliability of the type of plant proposed is of great importance. I noted this in an interesting way at San Antonio, some years ago, where for the high-service plant, drafting water from wells, and pumping intermittently, it was suggested that a pump of the steam-turbine-driven centrifugal should be used. The stock of the company was owned in Belgium; the bonds, in this country.

A Belgian engineer reviewed the plans which we had prepared and made the suggestion that Diesel engines should be substituted for the engines suggested, on the ground of economy, and stated that he had used them very successfully both in large and small plants in Belgium. My reply to him was that I recognized their economy, but the difficulty was that we had not yet, in this country, developed a sufficient number of men familiar with the Diesel engine to make me feel safe from a practical standpoint, and that an interruption of the service for the length of time required to transport a man who knew all about the Diesel engine and its difficulties, when he might be needed, from the point from which he could be obtained, to San Antonio, was too long; in other words, we could find, locally, many men who were capable of running a steam engine, an electric motor, or an oil engine, where we could find none familiar with the Diesel engine. The Belgian engineer accepted this explanation as being of controlling importance. The company finally installed the type of pump suggested (De Laval units), and has had continuous operation and successful service from it.

The same question of reliability is met in all of these smaller plants, and the difficulty is tided over in many ways, as for in-

stance by enlarged reservoirs, or, if there be more than one pumping station, by the fact that greater safety grows out of the duplication of plant in several pumping stations. And those factors will be of importance to you in making decision as to which type of machine you will put into use. The labor problem, which has been alluded to, is often a controlling factor. I think it has been my experience that, as viewed from the power end only, you generally have to get electric current for one cent a kilowatt-hour or less in order to compete successfully with the oil engine, and generally substantially less than one cent. On the other hand, when you take into consideration the labor factor the difference may be less. In other words, you can afford to pay more for your electric current and still use it advantageously. And if the question of intermittent use comes in, and cost of labor, as has been suggested here, then the electric motor may be more advantageous than any of the other types.

Each problem will have to be settled on the merits of the case, or, rather, on the circumstances which attend operation. The difficulties of the problem are those attendant upon expense. I think that the men who have handled these small works successfully, financially, deserve great credit for the way in which they have solved their problems.

MEETING WATER-MAIN COSTS BY ASSESSMENTS FOR BENEFITS.

BY M. N. BAKER, ASSOCIATE EDITOR, *Engineering News-Record*, NEW YORK.

War and prohibition have joined hands in making the financing of municipal improvements difficult. Bond issues cannot be piled up nor taxes incurred without limit. New sources of municipal revenue are being looked for. Old methods of raising funds must be utilized more fully.

Assessments for benefits as a means of meeting the cost of streets and sewers is an old and well-tried practice, supported in most if not all states by a sufficiently long line of judicial decisions to put it legally beyond question. In recent years benefit assessments have been applied to other improvements than streets and sewers, — notably to parks, — and they have been proposed if not actually legalized for rapid-transit extensions in New York City. A few cities meet, or have met, the cost of water-main extensions by levying the cost on abutting property. Is this sound policy? If so, why not adopt it more generally? I raise these questions not to support or oppose water-main assessments but to make a starting point for discussion by practical men who are daily confronted by such questions as revenue guaranties for mains extended into sparsely-settled districts or to a lone house at the end of some long street.

Before going further with water mains, it may be well to state briefly the underlying principle of benefit assessments. It is that a given public improvement renders a measurable benefit to all the property actually or potentially served by it, a benefit that increases the value of the property. The cost of the improvement may therefore be levied on the property in proportion to benefit, but not in excess. As a legal safeguard, some part of the cost is often placed upon the city as a whole. This may be fixed

arbitrarily by state law or local ordinance, or it may be determined for each case by the commissioners or assessors who fix the assessments.

Unfortunately, most assessments are made by some rule of thumb, or follow old practice because it has been given court sanction. Rarely are assessments based on sound engineering and economic principles. What these principles are and some of the details of their application were stated twenty-five years ago by F. Herbert Snow, then city engineer of Brockton, Mass., in a report on sewer assessments which remains unsurpassed to this day.

Mr. Snow's report is of particular value to water-works men because it considers water supply in relation to sewerage and sewage disposal, and because it outlines a plan for distributing the entire first cost of a sewerage system between the property benefited — divided into public benefit to the entire city, and private benefit to the individual property owner — and because it proposes a yearly charge for the use of the sewers similar to a charge for water. In further detail, the report goes into the relative merits of frontage and area assessments and, as I remember it, recommends a combination of the two. The scheme was put in use by the city of Brockton, and it or a like one was in vogue in several other New England cities a short time afterward, as witness a symposium on sewer assessments before the Boston Society of Engineers some twenty to twenty-five years ago — printed in the *Journal* of the Association of Engineering Societies.

As I have said, I neither advocate nor oppose paying for water-main extensions by assessments for benefits, but I think that any city which is puzzling over meeting the cost of such extensions might well study the plan. It might be particularly advantageous for small towns just building works.

Discussion.

Mr. Caleb Mills Saville.* *Mr. President and Gentlemen,* — The matter of Mr. Snow's report on Sewerage Assessments at Brockton, Mass., was mentioned by Mr. Baker, but he did not mention another valuable report along those same lines, made some years ago by Mr. Frank A. Barbour of this Association, in connection with sewerage assessments at Peabody. About a year ago, I think it was, there was an article by Mr. J. J. Ledoux, published in the *Municipal Journal*,† dealing with the matter of assessments, in which he deduced that assessments for private water companies should net at least 25 to 30 per cent. of the cost before the extension was made.

In opening I might perhaps say that this whole question has recently been before the Hartford Water Board for consideration and being in New York one day I met Mr. Baker and discussed some phases of it with him. Mr. Baker immediately seized on it as a good subject for discussion before this Association and that is the reason for my appearance today. Perhaps I might tell you how it came up and of some of its perplexities in Hartford. The method there used is probably that which obtains almost universally throughout the New England States, although there may be some modifications. The cost is assessed, or not assessed, by finding what the cost of the extension will be, and then having the people who desire pipe, guarantee payment of this cost or some other definite amount. Sometimes payment is made in a lump sum; sometimes as a certain percentage of the actual cost — that is, the assessment is so divided that the total payment may extend over a certain period of years; sometimes a certain size of pipe is decided on sufficient for the needs of the street — perhaps a 6-inch pipe — and if a larger-size pipe than that is used the excess cost of the larger-sized pipe goes into the general fund of the water department, this being an improvement to the city as a whole. Perhaps every year the cost of the preceding year may be taken as the basis, and the cost of the coming year based on that. The reason for using a uniform cost was in order to be

* Chief engineer of the Board of Water Commissioners, Hartford, Conn.
† July 6, 1918, p. 9.

fair to all people. For instance, if a man were so unfortunate as to live on a rocky hill, he had to pay perhaps two or three times as much for the pipe as a man who lived in a good gravel territory, where it was very easy to put the pipe in, and it seems desirable so far as possible not to penalize people who cannot always overcome natural obstacles.

Originally in Hartford there was a 10 per cent. guarantee on the cost of installation. Now the petitioner guarantees 10 per cent. annually on the cost of laying an 8-in. pipe in that street. That is, an 8-in. pipe is the smallest pipe that we ordinarily put in, except in streets that are 500 ft. or less. In that case it is the cost of a 6-in. pipe that is used.

Now, the difficulty that has come to us — and I presume it is the difficulty that may be met in a great many other places — is that of a man who has a vacant lot on a street. There happens to be no city water main in that street, because the land was formerly owned or developed by a building promoter. At first one house was built perhaps near the end of the street where there was a city water pipe and application made for a service connection, which was installed. Then another house was built and connected by the owner to the first service pipe. That method was continued until ten houses were connected on a 1-in. service pipe, all the way along the street, the pipe being perhaps eight hundred or a thousand feet long. Then comes a man who has bought a lot on the street about halfway down. This man builds the house and suddenly thinks he would like some water. He starts out to find where his water is coming from and he finds this private pipe, to which he thinks he will connect, but encounters strong opposition from those now connected who say, "We have now no more than enough water for ourselves; you cannot connect to this pipe." He then comes to the department for information as to what can be done. He is told to get a petition signed to have a water main put into the street. The cost of an 8-in. pipe this year is estimated as $3.00 per running foot. If the house is 500 ft. from the present main the total cost would be $1 500, or at 10 per cent. per year $150, to be guaranteed annually less the cost of water used paid for at meter rates. The reply to this is that he can't afford to put a pipe into this street, as his

water rent would probably not exceed $18 per year. He is then advised to get his neighbors on the street to join in the guarantee. He goes to them, and comes back with the report that they are supplied with water and do not propose to take on his troubles under this basis. What is to be done? The householder manifestly cannot afford to pay, and at the present time assessment cannot be levied on other consumers on the street or on vacant land which is benefited if a main pipe is put in.

Another case has been brought up: A building promoter petitioned for and had laid about a thousand feet of pipe in the street; from that he took off branch pipes and carried them all around the developed area and the department put on three master meters through which water was supplied to 28 to 30 houses. The promoter collected from these a proportional part and paid the department for the water registered by the master meters. Year before last he had considerable trouble with freezing of the services that he put in. Some of the people that he sold water to used water pumps to drain out their cellars and some used a great deal more water than the others did, but objected to paying a very large amount for the water they used, and he had considerable trouble. He came to the department and said, "I have no more interest in this development; I have sold it all, and just notify you at this time that I intend to pay no more water rents. If you like you may take over my water system, but I have no more interest in it." Now, the department did not wish to take over this system because they would have on their hands about 2 000 ft. of $1\frac{1}{2}$-in. pipe, and the minute they took it over it would be a city pipe and the people in that neighborhood would have called for an 8- or 10-in. pipe in order to get fire protection.

Now, as Mr. Baker has said, there are three or four ways of assessing benefits, and water supply in a street is a benefit undoubtedly, and a great benefit. One method of assessment is the frontage method. Offhand, one would think that was a fair way, to assess everybody on the street. All are benefited, and the vacant lots are so benefited that the selling price immediately is increased when water is available in the street. But in some ways this is not a fair proposition. You can conceive of a large vacant lot — a large farm, we will say — that the owners do not

propose to develop, perhaps, in the lifetime of the present owners, and yet beyond there is other land that the owners wish to develop. The vacant-land owner does not wish to pay for the installation of a pipe he will not use but, on the other hand, it benefits his land and increases its value.

Now, I am not yet ready to propose anything and just bring up these matters so that perhaps somebody will give us an answer or at least provoke discussion that may result in suggestions of value in meeting what now is a most perplexing condition. With the frontage proposition is a thought that Mr. Snow has very well brought out in his report on this matter, and that is that the front-foot proposition is not always a fair one. Suppose you have two lots, one of them perhaps 150 ft. long, with a private residence; adjacent is a small lot, perhaps 25-ft. front, on which is erected an apartment house of 6, 8, or 10 apartments, which will use three or four times as much water as the single house uses. In this case it is easy to see the frontage proposition will not always be fair or equitable to consumer or department.

Beside this comes the fact that it may often happen that there are rear lots, entrance to which is obtained by a passage from the main street; perhaps the passage may be only 15 or 20 feet wide, and yet in behind there may perhaps be a large area that could be developed. In the report of Mr. Snow there are all kinds of combinations that can be had and mention is made of these only to show some of the possible objections to the frontage plan.

The area plan offers some inducements, and perhaps the proper solution of the problem may be some combination of the area and the frontage assessments.

Besides the methods are the ways of collecting this assessment. The first method to be thought of usually is a lump-sum payment and its logical alternate, which is a method of deferred payments of the principal sum.

Another proposition is the case of corner lots. It is obvious that ordinarily a man will only take water from one street.

To get at the vacant-land owner, there is a possibility that, recognizing the hardship of paying an assessment on land that is not developed and bringing in a return, some modification might be devised. Possibly he might be required to pay something

when he did enter this water pipe, — perhaps not pay for what has passed, but for the future, and by then signing a guarantee to come in on the same basis that other people had come in on and so divide the burden with them. Perhaps some lump-sum payment might be required before connection would be permitted to one who had not signed the petition.

In most water departments at the present time another inequality in assessments presents itself. Suppose a main a thousand feet long, and a half-dozen people sign up and guarantee its cost. One man on the street, or two or three men, perhaps, own vacant land. They are approached by the people who want water and asked if they will sign this guarantee. This they refuse to do because they say they have no interest in it, they do not propose to build at present. In several cases, however, it has been found that after the pipe had been put in, these same people who refused to sign the guarantee immediately built, and the pipe being a city pipe, they have a perfect right to have entrance to it. They enter on that pipe and have all the privileges that accrue to the original people with none of the responsibility of guaranteeing its cost.

One other matter that comes up in this guarantee business is the effect of development propositions. Many builders will apply for extensions, and be perfectly willing to put up the guarantee. They are outside concerns, however, over which the city has no control. After building the houses they will sell them. Of course this guarantee is a lien on the estate to a certain extent, but the builders may not be responsible. Just at present in Hartford a bond for payment is required from these outside promoters.

As stated in the beginning, the matter of amounts for installation of extensions of water mains is a most perplexing one. It is, however, of very great importance to the department, especially at the present time. On the one hand, the department finance must be consulted, and no additional burden placed on present consumers which is not proper or fair to all. On the other hand, as it is desirable to encourage building development as much as possible, it seems very necessary to adopt some plan for meeting the cost of water-main extensions which will be attractive to prospective builders.

MR. CARLETON E. DAVIS.* Mr. President, I am not going into the theory of the assessment for benefits, but I can perhaps give some practical experience on the question.

Benjamin Franklin is supposed to have established the assessment charge that prevails in Philadelphia. We are working now under an ordinance that was passed in 1855, and before that time the same principle was in vogue and is generally attributed to Benjamin Franklin when he established the water works.

We charge a dollar a front foot on each side of the street. The corner lots, after having paid a frontal charge, are charged only 50 cents on the side. No property extending to a rear street is charged on the rear street unless the property has a greater depth than 100 ft. The assessment is a lien on the property, and is collectible by the usual methods followed in such cases. If, however, a water pipe is necessary in a rural or country district and we have to go past unoccupied territory, where there is no immediate demand for development, in order to supply water for distant places, the intermediate land that is not developed is not subject to the lien, but no buildings put up in the future on such property can secure water until they have paid the $1 a front foot. In a suburban property, neither city nor country, it is left to the discretion of the bureau as to whether the frontage charge is or is not equitable, or whether it should be postponed.

In certain cases we are without ready money to lay water pipe, and in order not to arrest development we have an arrangement whereby the majority of the owners can lay a pipe under private contract. They do the actual work, subject of course to our inspection. In that case they are required to file with us a certified statement of the actual cost of the work. Each abutting owner then is prorated on that expense, but a property that does not join in the cost cannot have an attachment for a period of ten years unless they have paid their pro-rata share. After ten years the rights of the parties laying the pipe lapse and then the Bureau collects the full price of $1.

Mr. Baker referred to the prohibition amendment as affecting water revenue. Philadelphia has been looking after additional

* Chief of Bureau of Water, Philadelphia, Pa.

revenue to take the place of the supposed loss from that source. The water bureau suggested the possibility of a special assessment for the high-pressure fire service. It was not taken up, and perhaps it was not made very seriously. But the fact was brought out that the high-pressure fire service had given preferential fire protection, possibly affecting insurance rates, in certain districts of the city. It was questionable whether that additional protection had been reflected in the tax rate. The proposition was made of a tax per cubic foot of area of buildings within the zone of the action of the high-pressure fire system. I have forgotten what that rate on a cubic-foot basis was, but it was a very small yearly sum.

Mr. A. R. Hathaway.* Mr. President, we in Springfield would not want the impression to go out — at least I would not, and I do not think Mr. Martin would — that we have been lax on this subject. It has been a problem, and is now.

Of course, in making main-pipe extensions in streets, there are two classes of streets, — the private street where a right of way and control is first obtained, and the public street. Then there are two primary reasons for making such extensions. In one case the municipal water works — (I do not call it the water *department*) — usually makes the extensions without petition or guarantee, to cover fire needs and the needs beyond the domestic uses. The other case is where real estate promoters start in to build up a tract or individual lot owners want water. In such cases they have to come in the office and get a guarantee-petition blank and have the same properly signed. We have our guarantees on practically the same basis as Mr. Saville spoke of. For a good many years they have been made on a basis of 10 per cent. of the cost of a 6-in. pipe, the 6-in. being the smallest we laid. Eight inches is probably the smallest we now lay except in certain cases, the same as in Hartford. We figured it out a good many years ago at about 15 cents a foot per linear foot of pipe wanted, and anybody coming into the office and wanting to get a pipe in a street was given a guarantee which he signed. One party or any number of parties could sign and distribute the amounts that they

* Water Registrar, Springfield, Mass.

guaranteed among themselves as they chose. But the aggregate of the guarantee must equal the above 10 per cent. of estimated cost for laying the pipe. Then, before the Board of Water Commissioners authorized the extension, we scanned the signers very closely, as it became a personal agreement and not a lien on the property; it could not be transferred from one person to another; the signers were held personally liable. After we accepted it and filed it away, the extension was made and the services were put in as property developed. People might buy lots, build houses and have them connected to the extension whether they were signers of the guarantee or not. But the water rents were all credited to that guarantee, and the balance between the rents received and the 10 per cent. total was laid on the signers at the close of each year. For a good many years we have been very successful in that method.

There is one thing we have not liked about it. The guarantee was perpetual and in some instances lasted too long. The signers were held to that guarantee until the water rental equaled the total amount of the guarantee, at which time the agreement automatically canceled itself. Sometimes it leaves out the owner of one lot or several lots who want to lay back and let the others take the initiative and develop the value of the property for him. That is the weak point. We have had a number of people of that kind, and they have not been in very good odor with the rest of the people on the street, but as fast as they sold out and the new owners became water takers, they would help the signers so much. Some method whereby each lot owner, benefited by such an extension, could be made to pay his proper share, would be desirable, but without some municipal ordinance or legislative enactment we could not do it very well.

Of late years, as we all know, there has been a growing laxness on the part of a certain class of foreign property owners, and after figuring the guarantees for the year and making up the balances and sending out the bills to the signers, we find that some of them have skipped out, become bankrupt, or something has happened to them, and we have to turn their balances over to the law department for collection. Our losses have been very small, however. I have had some tabulations made recently, to

show how we have been coming out with our main-pipe guarantees, and I thought the results might be of interest to you to-day. The first guarantee that was issued was made in 1892, and the total number of guarantees issued from 1892 to 1917, twenty-five years, was 485. The total number of guarantees canceled and filed away was 398, leaving 87 not yet canceled. Of the 398 which were canceled, 384 were canceled in the first five years of the life of the guarantee, or 79 per cent. of the total number issued. We consider this a very good showing. In the last five years, 1913 to 1917, (the tabulation being made only up to 1918), 158 guarantees were issued, of which number 90, or 56 per cent., have been canceled. A majority of the 87 uncanceled ones have been running but a few years, with a good prospect of being canceled by the increasing water revenue to their credit from such extensions.

Some of the others, running back in previous years, are within a year or two of their last bills for balances due, while a few of the older ones are considered as "hard nuts" and probably worthless.

We have lately decided that, instead of letting the real estate promoters and petitioners take the blank petitions out, we are going to have them come to the office and bring the signers to the office. We wish to be very sure that they personally understand the guarantee that they are signing. We have one case in particular where a party was a selectman of a town, and the town wanted to get an extension to supply hydrant purposes. And he went around and got some working people to sign the guarantee petition; and while they have taken the water as they agreed, the guarantee has not canceled itself, and they have been protesting against the assessment of the balance that is due, saying that they did not understand it, — that all they were to pay was the water rent. This man did not explain the guarantee to them as we would have done in the office. By insisting upon these guarantees being signed at the office, we will be sure that they understand it and that they are personally responsible before we put the guarantee up to the water board.

Another change we are considering is a guarantee limit, and I like Mr. Saville's idea of a ten-year term. Perhaps we might

put the percentage a little bit higher to start with or compute the annual amount of guarantee on a basis which will provide for the payment within a given term of years of a reasonable portion of the full cost of the extension wanted.

In certain cases where property does not develop as anticipated, and where, by means of sale or change, the particular interest of the guarantee-signers in such property ceases, it seems a hardship to continue to hold such signers to their guarantee-obligations after a reasonable number of years have elapsed.

MR. LEONARD METCALF.* Perhaps I can broaden the discussion a little, though I do not know that I have very much to add.

Mr. Davis just suggested to me the increasing difficulty which a large city would have with a great number of such accounts. In Philadelphia, he tells me, he has about 10 000 new accounts a year. You can see that the difficulty of keeping track of any such volume of agreements or contracts, extending over a period of ten or twenty years, would multiply very rapidly. In a small community it is not so burdensome.

You may be interested in the experience which we have had in my home town of Concord, where, when we built the sewer system, Mr. William Wheeler, who is a member of this Association, and who was for a great many years chairman of the water board and subsequently the sewer board, worked out a scheme under which the income from the water works has carried the interest and sinking-fund account on the sewers. The water-works earnings contribute about $11 000 a year to the sewer fund, and have liquidated about one third of the sewer debt.

It is interesting to note that we have had no litigation, which is rather unusual where some form of betterment tax is levied. To make the charge equitable there is remitted one fourth of the water charge in those houses which cannot be served also by the sewers, so that the houses that have only one service pay smaller water rates.

I was very much surprised, some time ago, when Mr. Frank C. Jordan, secretary of a committee of the American Water Works Association, and secretary of the Indianapolis Water Company,

* Metcalf & Eddy, Boston, Mass.

investigated the question of rates in different states, to see how many states there were in the country that already had the system of charging a frontage tax. It is my impression that there were something over 30 cities, and the amounts varied in different places, but usually they were determined by the approximate cost of a 6-in. or 8-in. pipe on a frontage tax regardless of the size of the pipe which was put in.

That, for instance, is the case at Los Angeles, where, if I remember rightly, 80 cents a front foot is paid on each side of the street by abutting property, or $1.60 per linear foot of pipe, which nearly, if not quite, takes care of the distribution pipe system cost. I remember that Mr. Hazen and I figured roughly that the water rates in Los Angeles would nearly have to be doubled if that proportion of the cost of the works were not borne by the abuttors directly, through this front-foot charge. Obviously, in passing, it is to be noticed that when you compare rates of cities, you must be careful about any such tax as this, because it has a material effect on the rates.

In reference to articles upon the subject, it occurs to me to call to your attention an article which was presented by Mr. J. B. Lippincott of Los Angeles before the American Society of Civil Engineers,* perhaps two years ago; and I think that Mr. J. L. Van Ornum also presented a paper before the American Society of Civil Engineers † some fifteen years ago, in which this general question of betterment taxes was thoroughly discussed. Both articles were good.

I was particularly impressed in our western cities, and in some of the middle western cities, with the advantage to the water department and to the city, of having some such tax as the front-foot-tax, on the basis of 6-in. or 8-in. pipe, because of the tremendous area included within city limits in many of our western cities. There is a marked difference in that respect between our eastern and our western cities, and it has led to increasing the cost of the public utilities to the residents of a city tremendously. You may take as an example of this the city of Denver, which is

* Trans. Am. Soc. Civil Eng., Vol. 81, p. 413.
† Trans. Am. Soc. Civil Eng., Vol. 38, p. 336.

built out in different directions with long stretches between the settled areas. It places a great burden on the city as a whole for its public service, its water pipes, gas pipes, electricity, and so on. A great part of the cost of those utilities would be saved if the city were more compactly built. Inasmuch as that is the result generally of land development or speculation schemes, it seems to me not unreasonable to throw some of the burden of that cost back again immediately on the land. I must confess that as I have reviewed the situation in some of our western cities more and more it has seemed to me that it was equitable to throw that burden on the land. It is true that there are cases in which unfairness would result; but that is true of any system that you can devise — there are exceptions to the rule. It is generally equitable to make those who benefit by the substantial increase in the value of the land through its conversion from country or grazing lands to suburban property, pay a portion of the burden of the utilities, rather than to throw that burden back again, upon the compactly settled city, which does not benefit directly by the development of those more remote areas.

The requiring of a guarantee, to which Mr. Saville has referred, is common practice. The percentage return exacted has varied very materially. In our own town, where we have for the most part a gravity system, a 4 per cent. basis has been used instead of 10 per cent. Of course, under those circumstances there is no return for the water, but the general system of carrying out the guarantee has been the same as that referred to here, and I do not think that it has been burdensome.

The practice of the commissions in this respect has varied materially. I was very much surprised a few years ago in appearing for the Milford Water Company, before the State Board of Health, which then had jurisdiction in water-company matters, at a ruling which was made by the board in regard to an extension desired in a section of the city where we showed that it could not possibly be commercially successful. The company had theretofore adhered to the general rule that unless a return of 10 per cent. upon the investment could be earned the extension would not be made. The board admitted that the return could not be earned, but took the position that if the citizens were willing

to bear the burden of additional payment for hydrants, or increase in rates, there was no reason why they should not have the extension. I called the attention of the Board to the fact that when you once departed from a rule of that sort it was exceedingly difficult to draw the line anywhere, and that there were other extensions in which the abuse would be greater; but the board adhered to its decision. The extension was made, and the return proved totally inadequate as predicted, and is a burden, therefore, upon the remainder of the community. Since then an additional extension has been asked for and has been a matter of embarrassment. I think that from a business point of view the course adopted was exceedingly unfortunate.

A similar situation arose, I remember, in the administration of the Indianapolis Water Company a few years ago, when complaint was made to the Public Service Commission by some of the real estate interests that the company would not make extensions except under a stated return. I think the return was less than 10 per cent. but it may have been 8 per cent. at that time. The water company said to the commissioners that if they wished to decide this issue they were entirely content to be relieved of the burden of it, because it was a very unpleasant duty. They asked first, however, to take the commission out on to the ground and show the commissioners the character of the development that was proposed and the business aspect of the matter. The commission undertook for a time to pass upon the question, and as I remember, within a few months, certainly within the year, threw it back on the company with the comment that it preferred the company should make the decision. In other words, I think that the political aspect of the matter sank in a little and that the commission realized that it was not a popular thing to have to deny these extensions, and when the commission faced the practical situation it very soon realized the truth of the water company's statement, that as a business proposition it could not be done unless the additional burden were thrown upon the rest of the city.

I remember another case, — that of San Antonio, Texas, — in which the policy, referred to here, was adopted, of permitting the real estate men to lay their own wrought-iron pipe systems

without giving any fire-protection service, and the water company simply connected up with those pipes and collected the revenue for the water which was distributed. That resulted finally in their having a very large amount of small pipe in the outskirts of the city. I state this with some reservation, as it is some time since I went over those figures, but it is my recollection that there were over a hundred miles of that wrought-iron pipe, and that when we came to discuss with the city authorities the renewal of the hydrant contract, one of the provisions of the agreement looked toward the gradual replacement of this large amount of wrought-iron pipe by cast-iron pipe. The laying of the wrought-iron pipe in many cases was distinctly advantageous financially, in that a return was enjoyed for a considerable period of years on a small investment, because there the pipes were laid very shallow, and the laying of the cast-iron pipe could be deferred until the revenue was sufficient to carry the added investment of the cast-iron pipe system, — particularly in view of the fact that the real estate had borne the burden of the wrought-iron pipe system as originally installed.

I think that the figure that Mr. Saville quoted in regard to the percentage of return suggested by Mr. Ledoux of 25 per cent. is a high one. More often a return of 10 per cent., in some cases a return of 12 or 15 per cent., has been exacted; but not often so high as 25 per cent.; although it is obvious that a return of 10 per cent. will usually not leave much if any margin over the cost of the water.

Mr. A. R. Hathaway. There comes to my mind certain recent opinions handed down by some of the public utility commissions in some of the western states. I have three cases in mind where they have stated that there is a question in their minds whether a water works, privately or municipally owned and operated, can reasonably refuse an extension of mains simply because the proper percentage of return on the cost basis is not met by the water takers or by responsible signers. In other words, they state that the water works should serve the public, and should put in such extension whether it is to be a paying proposition or not. That seems to me to be quite a drastic ruling.

MR. A. E. MARTIN.* Mr. President, I do not want the members of this Association to go home carrying the idea that there is any resident of Springfield who would feel any chagrin over getting his neighbors to sign a guarantee for water rental that would benefit him. But there is only one man in Springfield that I can remember at this time who ever refused to help out his neighbors by signing a guarantee. Mr. Hathaway has given you the particulars of our method there very much more minutely than I could if I had gotten on my feet before he did. But, in this particular that Mr. Saville refers to, I think he must have misunderstood me over the telephone, as our conversation was carried on in that way. This man to whom I referred is one who, instead of feeling any chagrin over accomplishing such an object as he evidently did, and — as I *know* that he did, (for he had houses on the line and came in afterward and had them connected and was able to get water from a pipe, the income from which was guaranteed by his neighbors), — instead of feeling any chagrin, as I say, he is a man who would smile to himself in a self-satisfied, sardonic way. Evidently he feels that way, for he has allowed, in more than one instance, his neighbor to help him out in such cases, and I know he feels no chagrin about it.

MR. GEORGE A. KING.† Mr. President, one point Mr. Hathaway made which I think might be qualified. As I understand, he stated that in case the land was sold by the man making the guarantee, that the guarantee could not be collected. If that party had built a house upon the property and then sold the property, I think the guarantee can be collected. We have had a decision to that effect from the city solicitor, claiming that special privileges might command special rates from the water commissioners.

In getting our guarantees we get a separate paper from each guarantor, and he guarantees a certain amount. We do not get one paper in which all join together in one guarantee for the whole; each one is a separate guarantee.

MR. SAVILLE. I would like to ask Mr. Metcalf if those houses served by the small pipes could not, instead of the department

* Superintendent of Water Works, Springfield, Mass.
† Superintendent of Water Works, Taunton, Mass.

taking them over, have been as well supplied if at the end of the city's main a master meter had been placed and the water billed to the man owning the small pipe, rather than putting the burden of the small pipe on to the city department.

MR. METCALF. If you are referring, Mr. Saville, to the San Antonio situation, it is my recollection that the water company did not take over the burden of the water system at all; it simply undertook to supply the water. But it had the machinery for the collecting of the bills, and it got its compensation directly from the people who used the water. But it paid nothing for the pipes, and it disconnected those pipes and left them in the ground and laid cast-iron pipes at a later date.

MR. SAVILLE. In the place of them?

MR. METCALF. In the place of them, when it finally got to the point of wanting to put in a larger pipe system giving fire-protection service.

MR. SAVILLE. Mr. Hathaway raised the question whether there was an obligation or not on water departments to supply certain portions of a city. I think that one answer to that is that there may not be an obligation from the fact that the maintenance and operation charges of the water department are not met from the tax levy but from the income from the water department itself. If they were met from the tax levy it seems to me as though there might be such an obligation. I don't know whether that is sound law or not, but it seems to me as though that might be so.

MR. PATRICK GEAR.* Mr. President, if we had the same rule in Holyoke that Mr. Davis has in Philadelphia it would be a golden rule and would be all right; then we would not have any trouble collecting our water taxes. But where you have been liberal for a number of years, running a thousand feet of water pipe here and there in all parts of the city without any charge, and selling the water at a very low rate, then I say you would have a very hard time trying to raise your water rates.

In looking around to see where we could get some money, we decided to assess the property owners for new extensions on the

* Superintendent of Water Works, Holyoke, Mass.

$1.00 per front foot basis, which I thought at the time was a little high. But I never dreamed that Mr. Davis was charging the same as we are. Before this rule went into effect a man built a house on a street fifty feet beyond the end of pipe laid and we extended the main as far as his house free of charge. After this rule was in vogue along comes another man and builds a house on the same street fifty feet east from end of pipe laid and we extended the main as far as his house, charging him $50.

There is another proposition before our board, which is a large one, and that is, where pipes are laid on streets for a number of years — where a man builds a house and applies for a water connection, that he will pay an assessment for same before the water is turned on to his premises. But I can readily see from what is said here this afternoon that it is a larger proposition than I figured it to be. Nevertheless, I think it will do away with a great deal of bookkeeping. I can't say whether it is a good idea or not, to make a service charge for every service connection that is put in hereafter.

We have over twelve hundred vacant lots in our city, and the main pipes have been put in for years and years. Now the owners of these said lots, under our present system, would get away without paying anything in case a service connection was made — but a fellow that is going to build on a new tract where the main will have to be extended must pay for extension and also the service connection. I am of the opinion that we can put a charge on all owners of said vacant lots and future extensions and thereby do away with the front-foot charge.

MR. METCALF. It might be interesting to ask Mr. Gear if, inasmuch as they are in need of revenue and want to be fair to everybody, it would not be a good scheme to put that service charge on all the houses where they have a service now.

MR. GEAR. Well, Mr. President, with those service charges, and also other things, we have found that money could be gotten without charging the poor man. For example, early last year we increased our revenue without charging any poor man a cent. There was only one automobile fellow who did not want to pay, but he paid it just the same.

MR. JOHN C. CHASE. One interesting thing in connection with

Mr. Gear's remarks was in regards to the bookkeeping. He says they have no trouble in knowing where the money goes to.

MR. GEAR. No extra bookkeeping, I think I said. Our present clerks will do all the work required. We have hopes of getting this new system started without any extra clerks.

MR. FRED L. CUSHING.* Mr. President, we have in our rules and regulations a provision which explains why we charge the 6 per cent. We charge 6 per cent. for an extension and require a guarantee by the person wanting the water, and a bond that they fulfill the guarantee for a term of thirty years, which will pay 3½ per cent. interest and 2½ per cent. sinking fund, making 6 per cent., the city acting on the theory that they advance the cost of the work and get it back in their ordinary charges. We have a good deal the same troubles that the others do, and I do not think that is the best method. If we could have it made a lien on the property, we would make all the property that was benefited pay the expense, but as we can't even make the water rates a lien on the property we don't see much use in trying to make the construction charge.

MR. FREDERIC P. STEARNS.† Mr. President, in discussing this subject I will have to hark back to the time when I was with the State Board of Health, some thirty years ago. At that time I was a good deal interested in a comparison between the methods of raising money for sewerage systems and for water works. I am referring now mainly to the original systems, rather than to extensions.

In cases where sewerage systems were to be built, it was the usual rule to assess the cost of the system, or of a large part of it, upon the owners of property bounding on the streets in which the sewers were laid. This required large payments by the owners, and often was so great a burden upon them as to create opposition to the installation of a system and prevent its construction. The establishment of a very much needed sewerage system was in this way deferred. In any case, under this arrangement the town assumed the responsibility for the annual cost of operation and

* Water Registrar, Medford, Mass.
† Consulting Engineer, Boston, Mass.

maintenance, and generally the interest and sinking fund charges on a part of the system.

Municipal water works, on the other hand, were generally built by the issue of bonds, no charge being made against property except an indirect charge for hydrant service, and an annual assessment was made upon the water takers to defray the expense. This method was very successful, as nearly all the municipal water works in Massachusetts were receiving revenue sufficient to pay the running cost, the interest on the bonds, and a very considerable amount for sinking the bonds. As a general rule, the amount paid into the sinking fund was much in excess of the actual depreciation, so that the net debt was less than the actual value of the works. In other words, this method was one which did not delay a needed municipal enterprise, and did not cause the people to kick nearly as much at the annual water rates as they did at the large sewer assessments.

As showing the excellent financial condition of the water works under this system of raising money, I recall a study which I made as a part of an investigation for a Metropolitan water supply in 1894. The cities and towns in the Metropolitan District within about ten miles of Boston spent for extensions of works during the ten years from 1883 to 1893 about $13 000 000, and the net debt of these places in the same time increased only $2 000 000. That is to say, the revenue from water rates had been sufficient during these years to pay by far the greater part of the cost of extensions. This is an example of the large amount of money which can be raised through annual assessments without being especially burdensome.

I do not wish to argue against the justice of assessing costs upon property benefited, but under the conditions existing in New England that is not the practical way to obtain the best results, because money can be acquired much more easily and in greater quantity through annual assessments than from large special assessments. Even in the matter of extensions, I believe that a liberal policy should be employed. It does not do any serious injustice if a small part of the revenue obtained from the existing water takers is applied to extensions so as to prevent too large a charge against those benefited by the extensions.

Mr. X. H. GOODNOUGH.* Mr. Baker's suggestion is a most interesting one. One of the serious difficulties encountered by health departments at the present time is that of securing extensions of water-works systems in sparsely settled districts. The public water supply is by far the most important of all public services in its relation to public health and is also one of the most important of all in its relation to public comfort and convenience; but it is the common practice when a petitioner desires the extension of a water main in a sparsely settled district to charge the whole interest on the cost of laying the main to the person who asks for the water and, unless he can give a suitable guarantee, the work is not carried out. Of course, when such extensions are made, if other takers come in along the line of pipe they are supplied with water generally at the usual rates, and while the charge to the original petitioner is reduced he still may pay a disproportionate share of the cost. Very often along such extensions there are dwelling houses where the owners choose to continue the use of their own private water supplies and decline to take water from the public works, and while their estates are improved they pay nothing for the added value.

This plan of charging for a water main seems unfair and unreasonable. Under its operation it is sometimes impracticable to secure the extension of the public water supply into districts supplied from polluted local sources, which may constitute a serious menace to the public health, except in cases where some private individual pays the larger part of the bill. Even in such cases, most of the inhabitants would willingly become water takers provided they could obtain their supplies at the same rates as other citizens of the town, but cannot afford to pay the whole charge for an extension until such time as enough takers come in to reduce the charge to the regular rate.

One of the improvements following the introduction of water supplies in towns and villages noted many years ago was the decrease in the prevalence of typhoid fever in such communities, and there are still small villages and districts dependent for water supply on private wells in which a relatively high rate of typhoid

* Director and Chief Engineer, Mass. State Dept. Health.

fever still persists. Experience has shown that many of the private wells and other supplies used in villages and rural districts are polluted, and much of the typhoid fever occurring in the late summer and early autumn may still be due to this condition. For example, one small town in Massachusetts, used to a considerable extent as a summer resort and still supplied with private-well waters, has had a persistently high typhoid rate for many years. A thorough examination of all the facts has failed to show any other cause for the prevalence of typhoid in this town than the polluted wells.

Many cases have arisen in which it has been found important for a city or town to extend its water-supply system to a sparsely settled district for the protection of the public health, and in such cases a part at least of the cost of the extension might reasonably be charged to the town as a health measure. A benefit also accrues usually in respect of charges for insurance following the introduction of a water supply of sufficient capacity for fire service. Furthermore, the laying of a water main in such a district unquestionably enhances in most cases the value of the property. It would seem reasonable not only that the town should pay a part of the cost of such extensions as a health measure, but also that a considerable part of it should be assessed upon the estates benefited in proportion to the benefit which they receive.

It does not seem fair or reasonable to operate public water supply in any city or town solely as a business proposition and as a means of protection from fire. The water supply is, in addition, a most important means of protection of the public health, and its use for that purpose should be given due consideration. If a sewer is a benefit in any street, and if when a sewer is laid it is reasonable to tax all the abutters whose lands can be drained into the sewer, it is unquestionably even more reasonable that when a water supply is laid in a street the abutting owners should also pay a proportion of the cost of the improvement.

This consideration would apply not only in municipalities where the works are owned by the public, but also in municipalities supplied by private companies.

In states where the regulation of the service of water companies

is wholly in the hands of the state health department, it is practicable for that department, on the ground of public health, to require an extension of the water service to a sparsely settled part of a town where the public health requires such extension, but of course in such cases the remaining water takers must pay for a part of the cost of such improvement where the number of water takers and fire hydrants does not supply a sufficient return on the cost. In states in which the water-works regulation is in the hands of a public-service board, it would probably be impracticable for such a board to act as a board of health, but this difficulty might be removed by suitable legislation.

There are other considerations which affect the extension of water mains in sparsely settled districts, especially the question of the use of the public water supply for irrigation in densely populated regions like Massachusetts. There is no doubt that means for irrigation are almost as necessary in the east as in the west, since extreme droughts for short periods often occur in the eastern states which result in the ruin of the year's crops, a condition which could be avoided if irrigation were available. If agriculture is to be restored in New England, means for irrigation will have to be provided. While in many places it is not difficult for each farmer to provide his own irrigation system, there is no doubt that it can be provided at much smaller expense from public works. Water from public water-supply systems is already used to a very considerable extent in Massachusetts for irrigation on farms where the public water-supply pipes are available for such use. In fact, some of the public water supplies in the Connecticut Valley were introduced largely for the purpose of the irrigation of tobacco and onions in the early part of the year when crops are sometimes lost if a drought occurs. If the water-supply systems are to be used generally for irrigation, as will very probably be the case, the laying of the pipes in the beginning at least will involve a large expense which payment for the water used will in many cases fail to meet, since in Massachusetts the quantity of water required for irrigation would rarely be great, excepting in very dry years. With a provision for the assessment of a part at least of the cost of such works upon the municipality for the protection of the public health, where such protection is afforded,

and a part upon the estates benefited, the cost of extensions of water-supply systems need not fall wholly upon the individual who has the enterprise to introduce the water or upon the remaining water takers. It can be made to fall in many cases in part upon the municipality for the protection of health, and probably in large part upon all properties benefited by such extension.

PROCEEDINGS.

March Meeting.

Hotel Brunswick,
Boston, Mass., March 12, 1919.

The President, Mr. Samuel E. Killam, in the chair.
The following members and guests were present:

Honorary Members.

E. C. Brooks.
R. C. P. Coggeshall.
F. E. Hall.
F. P. Stearns.
R. J. Thomas. — 5.

Members.

E. R. B. Allardice.
M. N. Baker.
L. M. Bancroft.
J. F. Barrett.
G. W. Batchelder.
C. S. Beaudry.
F. D. Berry.
A. E. Blackmer.
George Bowers.
G. A. Carpenter.
H. H. Chase.
J. C. Chase.
F. L. Cole.
John Cullen.
F. L. Cushing.
C. E. Davis.
John Doyle.
E. D. Eldredge.
Frank Emerson.
W. E. Foss.
Patrick Gear.
H. T. Gidley.
F. J. Gifford.
H. J. Goodale.
R. A. Hale.
A. R. Hathaway.
D. A. Henderson.
C. R. Hildred.
J. L. Howard.
W. F. Howland.
J. A. Hoy.
J. W. Kay.
Willard Kent.
S. E. Killam.
G. A. King.
H. V. Macksey.
A. E. Martin.
J. H. Mendell.
F. E. Merrill.
G. F. Merrill.
Leonard Metcalf.
M. L. Miller.
William Naylor.
W. H. O'Brien.
T. A. Peirce.
H. E. Perry.
E. W. Quinn.
L. C. Robinson.
H. F. Salmonde.
P. R. Sanders.
C. M. Saville.
A. L. Sawyer.
C. W. Sherman.
Channing Smith.
J. Waldo Smith.
Sidney Smith.
J. F. Sullivan.
S. H. Taylor.
E. J. Titcomb.
D. N. Tower.
R. S. Weston.
H. T. Wheelock.
G. E. Winslow.
C. L. Wooding. — 64.

ASSOCIATES.

Bond, Harold L., Co., by F. M. Bates.
Builders Iron Foundry, by A. B. Coulters.
Byers, A. M., by H. F. Fiske.
Donaldson Iron Co., by C. F. Glavin.
Eddy Valve Co., by H. R. Prescott.
Fire and Water Engineering, by C. B. Hayward.
Hayes Pump Machinery Co., by F. H. Hayes.
Hersey Mfg. Co., by J. Herman Smith.
Lead-Lined Iron Pipe Co., by T. E. Dwyer.
Mueller, H., Mfg. Co., by C. J. G. Haas.
National Meter Co., by J. G. Lufkin and H. L. Weston.
Neptune Meter Co., by W. H. McGarry, Jr.
Pittsburgh Meter Co., by G. C. Northrop.
Rensselaer Valve Co., by C. R. Brown and I. A. Rowe.
Smith, A. P., Mfg. Co., by F. L. Northrop.
Thomson Meter Co., by E. M. Shedd.
Union Water Meter Co., by H. W. Jacobs.
United Brass Mfg. Co., by G. A. Caldwell.
Warren Foundry and Machine Co., by H. H. Kinsey.
Wood, R. D., & Co., by H. M. Simons.
Worthington Pump and Machinery Corp., by Samuel Harrison and E. P. Howard. — 24.

GUESTS.

MASSACHUSETTS

Billerica, G. A. Stowers.
Somerville, F. M. Hutchinson.
Swampscott, John Albee.

RHODE ISLAND.

Bristol, J. M. Jones.

NEW YORK.

Woodhaven, James Cochran. — 5.

The Secretary presented applications for active membership, properly endorsed and recommended by the Executive Committee, from William Colquhoun, Yonkers, N. Y., superintendent Water Bureau; Charles B. Garmon, Lowell, Mass., resident engineer of general construction work and engineer in charge of fire protection and water-works system of Proprietors of Locks and Canals on Merrimack River; Stephen H. Taylor, New Bedford, Mass., assistant superintendent New Bedford Water Works; Charles L. Wooding, Bristol, Conn., chairman of water commissioners; Morrison Merrill, Wakefield, Mass., superintendent

water and sewer department; A. J. Mylrea, Toronto, Ont., special risk engineer.

On motion of Mr. Lewis M. Bancroft, the Secretary was directed to cast the ballot of the Association in favor of the applicants named, and he having done so they were declared duly elected members of the Association.

PRESIDENT KILLAM. I am pleased to announce that the annual convention will be held in Albany, N. Y., probably the second week in September. [*Applause.*]

Mr. William E. Foss, chief engineer, Metropolitan Water Works, Clinton, Mass., read a paper, illustrated with stereopticon, entitled, "Brief Description of Break in 1 200 H.P. Turbine, Wachusett Power Plant, Metropolitan Water Works." Messrs. Carleton E. Davis, F. H. Hayes, Robert S. Weston, Richard A. Hale, and Percy R. Sanders took part in the discussion.

Mr. M. N. Baker, associate editor, *Engineering News-Record*, New York, read a paper on "Meeting Water-Main Costs by Assessments for Benefits." The discussion was led by Mr. Caleb M. Saville and participated in by Messrs. Carleton E. Davis, A. R. Hathaway, Leonard Metcalf, A. E. Martin, Geo. A. King, Patrick Gear, John C. Chase, Fred L. Cushing, and Frederic P. Stearns.

Adjourned.

EXECUTIVE COMMITTEE.

Meeting of the Executive Committee of the New England Water Works Association at headquarters, Tremont Temple, Boston, Mass., Wednesday, March 12, 1919, at 11 o'clock A.M.

Present: Samuel E. Killam, President; Henry V. Macksey, Charles W. Sherman, Percy R. Sanders, James H. Mendell, Frank J. Gifford, A. R. Hathaway, Patrick Gear, Lewis M. Bancroft, and Willard Kent.

Five applications for membership were received, viz.: A. R. G. Booth, assistant chemist, Massachusetts State Board of Health, Boston, Mass.; George M. Graffan, auditor, Portland Water District, Portland, Me.; W. W. Nye, trustee Kennebec Water District, Waterville, Me.; A. B. Thompson, assistant superintendent, Kennebec Water District, Waterville, Me.; and one application for reinstatement to membership, viz.: Thomas J. Carmody, water commissioner, Holyoke, Mass.

On motion of Mr. Sanders, seconded by Mr. Gifford, it was voted: That the President represent the Association at the Tenth Annual Joint Dinner of the Boston Section of the American Society of Mechanical Engineers, the Boston Section of the American Institute of Electrical Engineers, and the Boston Society of Civil Engineers, at the Boston City Club on the evening of April 2, 1919.

Voted: That the President be and hereby is authorized to appoint a delegate to meet with the National Service Committee on Engineering Council in joint session at Chicago, Ill., April 23 to 25, 1919.

Messrs. A. R. Hathaway and Patrick Gear, the Committee to investigate and report on a place for holding the next Annual Convention of the Association, presented their report and, after discussion — on motion of Mr. Gifford, seconded by Mr. Macksey — it was unanimously voted: That a four days' convention be held at Albany, N. Y., in September next and the President is hereby authorized to appoint a Committee of Arrangements with full powers.

Adjourned. Attest: WILLARD KENT, *Secretary.*

HARVEY M. GEER.

The death of Harvey M. Geer, a member of the New England Water Works Association since October 10, 1897, occurred on March 18, at Troy, N. Y.

The following is quoted from a local paper:

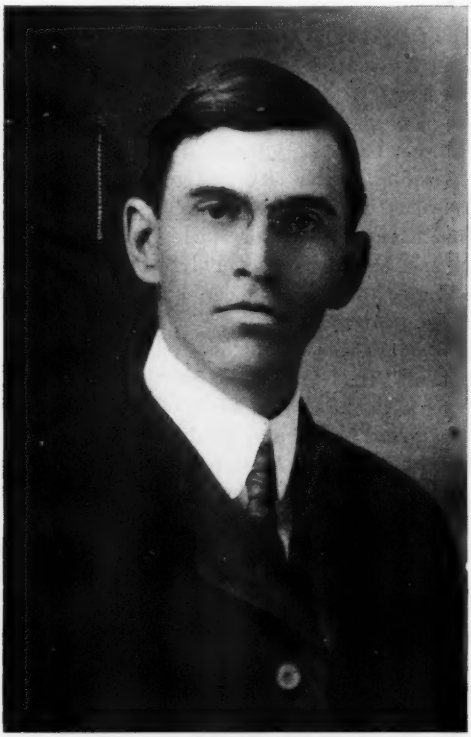
Harvey Mosher Geer, of Ballston, a native Trojan, died at the Samaritan Hospital in this city yesterday. Mr. Geer was born in Troy, February 22, 1851, and was a son of the late Gilbert Geer, Jr., and Frances A. Mosher. He graduated from the Troy high school and the Rensselaer Polytechnic Institute, class of 1872, with degree of civil engineer, and was a member of the Zeta Psi college fraternity.

Mr. Geer was engaged as engineer on the construction of the original Congress Street bridge and built the Third Street bridge under contract with the city of Troy; also the water-supply systems for Johnstown, N. Y., and Fairhaven, Vt., and additions to the water-supply system of Amsterdam, N. Y. He was engaged on water-supply systems for Macon, Ga., and Westboro, Mass. For many years Mr. Geer was engaged in the manufacture of news print at Ballston Spa, with the late Harvey Donaldson of that place, under the name of Donaldson & Geer. Of late years Mr. Geer had been a consulting engineer, with offices in Ballston Spa, and was engaged in the development of hydro-electric projects, water-supply and sewage-disposal systems, and in expert court work. His last work, immediately previous to his death, was on a hydro-electric development for the American Manufacturing Company at Mechanicville, N. Y.

Mr. Geer had been a member for many years of the American Society of Civil Engineers and New England Water Works Association. He married Caroline Akin of Johnstown, N. Y., and is survived by her, a daughter, Helena Geer, and a son, Howard E. Geer, all of whom reside in New York.

RUFUS MASON WHITTET.

Rufus Mason Whittet, son of Alexander and Isabella (Proudfoot) Whittet, was born October 17, 1878, in Lowell, Mass., and died at Boston, Mass., on December 10, 1918. He came of



Scotch ancestry, being a lineal descendant of James Whittet, of Kintillo, Scotland.

He was educated in the Lowell public schools, having graduated from the Moody Grammar School in 1893 and from the Lowell High School in 1897, at the age of nineteen. Deeming it wise to

further continue his academic studies, he returned the following year to the Lowell High School, taking the post-graduate course.

Mr. Whittet then passed the entrance examinations for both Harvard College and the Massachusetts Institute of Technology. Deciding in favor of Technology, he entered that institution in 1898 and graduated in June, 1902, with the degree of bachelor of science in the department of Sanitary Engineering, presenting as his thesis, "A Study of the Stream-Flow Records of the United States Geological Survey."

Upon his graduation from the Massachusetts Institute of Technology, Mr. Whittet joined the engineering staff of the State Board of Health, and in the wide field of work covered by that department he found employment congenial to his tastes. Taking a deep interest in its work, he soon became a most valued member of its staff and was the principal assistant engineer of the department at the time of his death.

He was a civil engineer who believed in the elevation and dignity of his profession, and he acted on this belief with a fine enthusiasm. His principal characteristics — clear thinking and sound judgment — were combined with great executive ability, and his early death ended a career begun with great promise.

Mr. Whittet was a member of the American Society of Civil Engineers, the Boston Society of Civil Engineers, the New England Water Works Association, and a prominent member of the Masonic Fraternity.

He was married in September, 1916, to Effie Osgood Byron, of Jamaica Plain, Mass., who, with a daughter, Helen Isabella, born January 16, 1918, survives him.

In appreciation of his service to the state, the State Department of Health adopted the following tribute to his memory:

"Rufus Mason Whittet, C. E., principal assistant engineer of this department, died on December 10, 1918, a victim of the prevailing influenza epidemic.

"Mr. Whittet joined the engineering staff of the State Board of Health upon his graduation from the Massachusetts Institute of Technology in 1902, and has been the principal assistant engineer of the department since 1908.

"His energy, thoroughness, clear thinking, and sound judgment, were of invaluable assistance in the studies of water supply and

drainage and the great variety of kindred problems embraced in the work of the department, while his quiet manner, his fairness and his kindness made work with him a pleasure. These qualities, with a high sense of honor and loyalty to his associates, made him respected by all and loved by a wide circle of friends."

T. P. MARTIN.

Died August 11, 1918. Superintendent Water Works, West Springfield, Mass. Member of New England Water Works Association since September 9, 1914.

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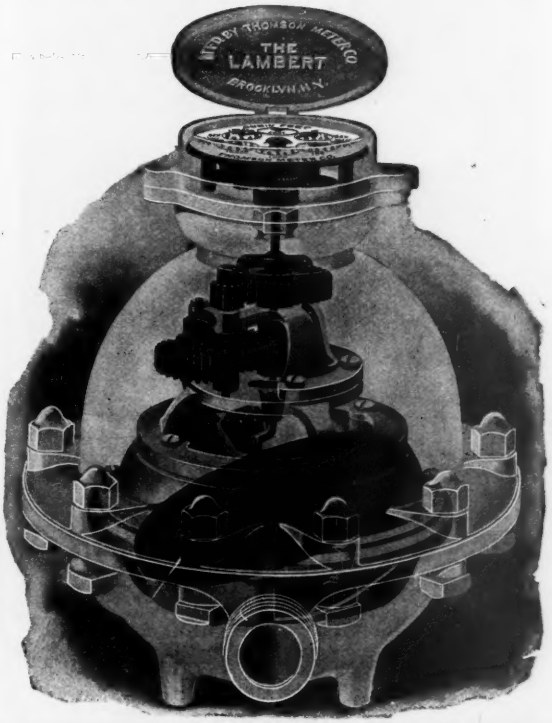

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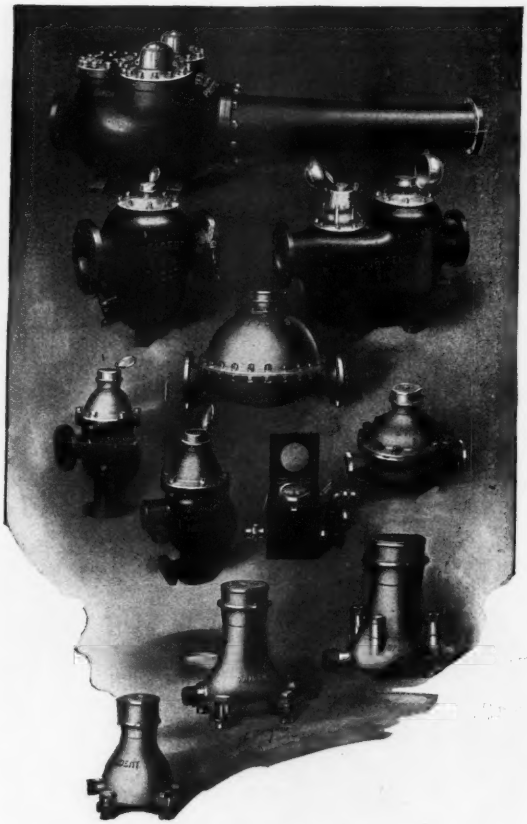

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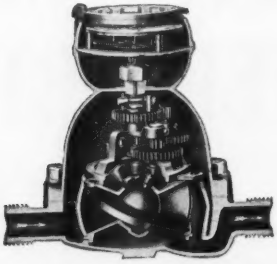

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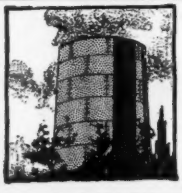
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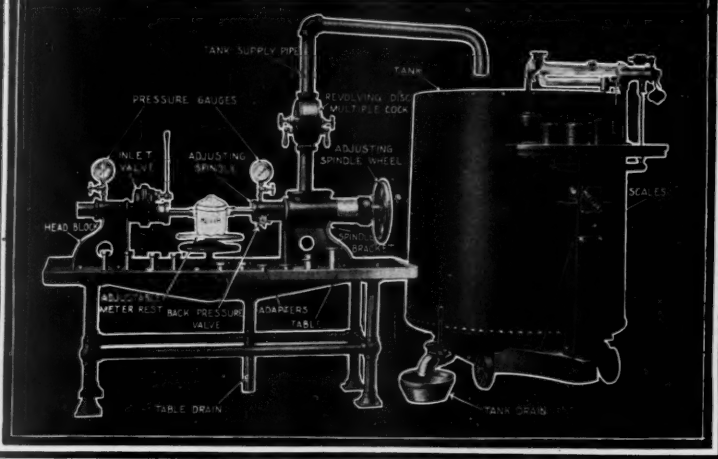

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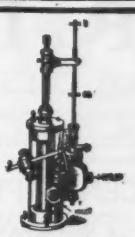

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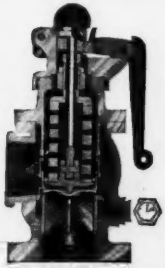

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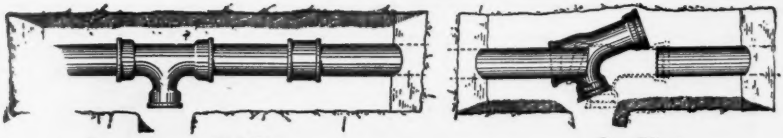

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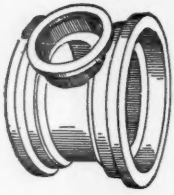

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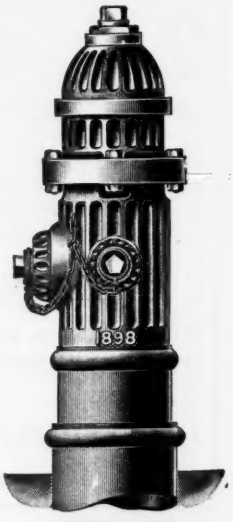

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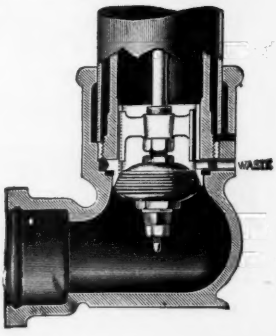

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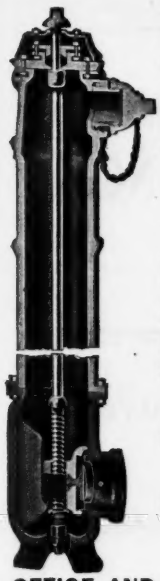

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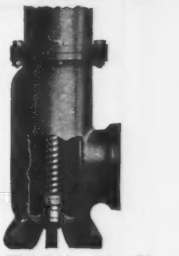

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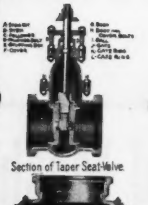

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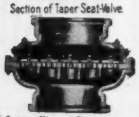

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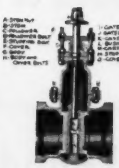
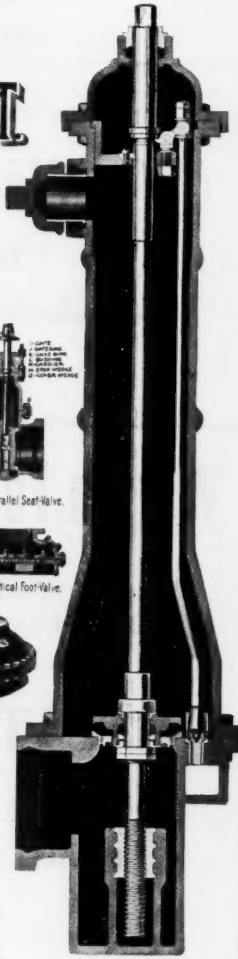


Section of Parallel Seat-Valve.

Section of Vertical Foot-Valve.

Vertical Foot-Valve.

Water Crane with Automatic Drop Valve.



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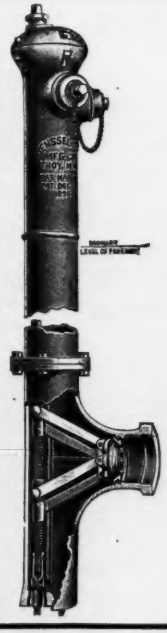

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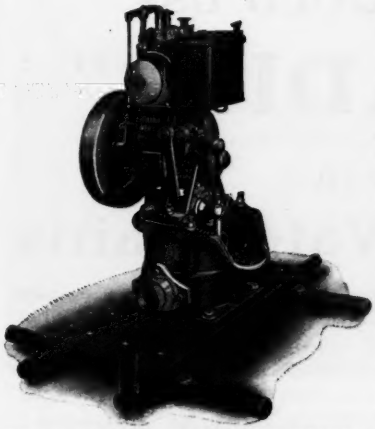

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YOU SHOULD USE

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Registered U. S. Patent Office

FOR

Jointing Water Mains

1. **DURABILITY.** Leadite joints increase in strength with age.
2. **NO CAULKING.** Leadite joints require no caulking, because the Leadite adheres to the pipe, making a water-tight bond.
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10. **DELIVERY.** We can make prompt shipments.
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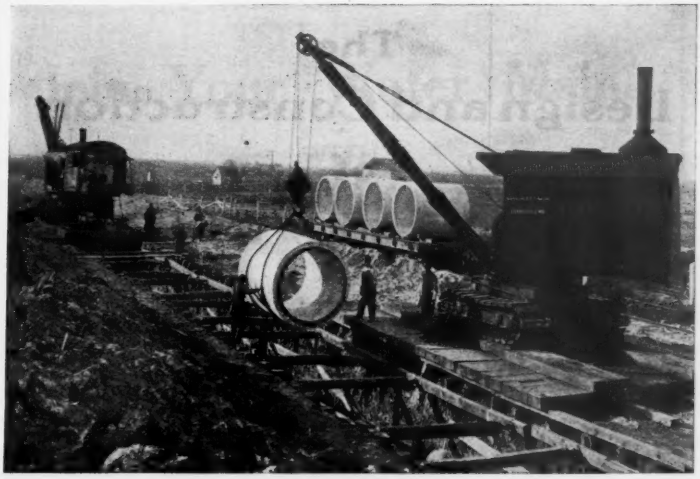

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ORGANIZED JUNE 12 1882.

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(resident, non-resident or associate)
..... *membership.*

I am ..... *years of age, and I have been engaged in the following named work:*

.....

.....

.....

I will conform to the requirements of membership if elected.

Signed, ...

Address, ...

Dated, ... *191*

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